HOUSE OF COMMONS

Defence Committee

Oral evidence: Defence and Climate Change, HC 179

Tuesday 22 November 2022

Ordered by the House of Commons to be published on 22 November 2022.

Watch the meeting

Members present: Mr Tobias Ellwood (Chair); Robert Courts; Dave Doogan; Richard Drax; Mr Mark Francois; Mrs Emma Lewell-Buck; Gavin Robinson; Derek Twigg.

Questions 1 - 55

Witness

I: Lieutenant General Richard Nugee, (Retired), Lead, Ministry of Defence's 2021 Climate Change and Sustainability Review.

Examination of witness

Witness: Lieutenant General Richard Nugee.

Q1 **Chair:** Welcome to this Defence Committee hearing on 22 November 2022. Today, we will focus on defence and climate change, which is pertinent, given the completion of COP27. I am delighted to welcome Lieutenant General Richard Nugee, now retired. You and I worked closely together, as you did with other former Ministers here. Welcome back to the spot. You are not wearing your uniform this time. You are now responsible for leading on climate change and sustainability in the MOD. Could you begin by describing in detail what that role involves?

Lt Gen. Nugee: I am the non-executive director for climate change and sustainability in the MOD, which is a role that sits in the Defence safety and environment committee, one of very few committees that the four stars sit on, as well as the second permanent secretary and vice-chief chair. My role there is to inform and challenge Defence over their climate change and sustainability goals. I also sit as what is called the non-executive director for Defence for net zero on a committee of non-executive directors from across Government. Each Government Department now has a non-executive director for net zero, and I am the Defence representative on that.

Q2 **Chair:** Thank you. We will go into detail on what the MOD is doing on climate change, but just to paint the picture, it has been talked of as arguably the biggest long-term threat that we face and need to recognise. We face a lot of complex threats, but this is certainly something we need to get our heads round. Even in the last seven years, we have seen deserts growing, ice caps melting, sea life dying and weather patterns changing. It will create tensions for Governments, in terms of remaining in control of their populations. We will see mass movements of people, as areas become inhospitable. Do you think that the country and the MOD are really embracing the scale of change that is about to come over the horizon?

Lt Gen. Nugee: It is very difficult to picture the scale of change that is likely to happen in the future. From an MOD perspective, even 1.5°C—of course, we are not there yet; we are still in the emergency room, as I think the UN Secretary-General described it at COP. Current projections are that, if everybody does what they say they will do, we are going to get to a rise of 2.7°C, which is significantly higher than the 1.5°C that is the Paris goal.

The MOD was asked by the Committee on Climate Change to look at the effects of a rise of 2°C and 4°C on our thinking, and that is what the MOD has done. There are a number of challenges or effects that come out of going to even 1.5°C, let alone 2°C or more. The first is on our infrastructure, both overseas and on the home base. That includes the infrastructure of our ports as a result of rising sea levels, and the worrying assessment by scientists of the tipping points for the West Antarctic ice sheet, which will tip at around 2°C, and the Greenland ice cap. If both

those melt, which will take a long time, ultimately we are looking at perhaps 10 metres of sea level rise. That will affect our ports. That will take time—it is not immediate, of course—but the tipping point problem is that once we are on the route to that, it is impossible to get back. It is something that will definitely happen if we reach that tipping point.

Q3 **Chair:** In practical terms, that would mean that the runway in Gibraltar, for example, would be—

Lt Gen. Nugee: Would be underwater. Port Stanley in the Falklands, or even Portsmouth and Devonport, could not cope with a 10-metre rise in sea level. I am not saying that that will happen immediately—we need to be really clear about that—but the combination of rising sea level over time and more severe storms, which is another feature of climate change, means that our ports will be more difficult to use, frankly, and ultimately perhaps underwater. But that is not particularly immediate. What is immediate is what has happened in the US: for one fort, Camp Lejeune, the assessment is of over $1 billion-worth done by climate change, by enormous storms caused by climate change. In very strong winds in this country, we can see the roofs of our aircraft hangars being damaged.

Q4 **Chair:** This has happened already?

Lt Gen. Nugee: The one in America has happened already. Seventeen F-22s were damaged by a storm—

Q5 **Chair:** This is on the east coast—North Carolina, is it?

Lt Gen. Nugee: I am not altogether sure. I think it is on the east coast—yes, it is from those storms that hit the east coast. The potential is not as great in this country; we do not have the same hurricanes as there, but there is still potential for damage to our infrastructure, which we need to be alive to, because that will affect our operational capability.

That is one side to it—the straight damage to, or the limitations on, our equipment. I will give one example: in the Gulf, the Met Office did a study for me, which showed that in about 10 to 15 years, the surface sea temperature in the Gulf will routinely be 36°, and potentially between 38° and 40°. As we all know, we cool maritime engines using water from the sea or whatever water they are in. Cooling water at 40° will actually act as a thermal blanket, rather than—

Q6 **Chair:** Are you suggesting that the Type 45 might have even further problems when it is there?

Lt Gen. Nugee: I am suggesting that all ships might have a problem, because they will not have the cooling water. Already, ship captains are saying to me that the engines have the potential to cut out when the surface sea temperature is what it is today, let alone 38° and 40° on really hot days in the Gulf. That is something that we need to understand and do something about, so that our engines can cope with that sort of water.

Another aspect is about people. I was in Iraq in 2003, and we were in 50° to 55° of heat during the summer, without air-conditioning. Frankly, more

people went to the regimental aid post for heat than they did for anything else during my tour. We had to send some people back because of heat exhaustion—just straight heat and humidity.

Finally, quickly, though I am sure we will come on to this, there is national security. As you said, the hotter the world, the scarcer certain resources will be, and therefore the more competition there will be for those resources. The more competition there is for resources, the more likely it is that conflict will happen. While I do not see people taking to the streets in the UK because of that, I do see food becoming scarcer and therefore more expensive in this country. There will be mass movement of people, some of whom will come to northern Europe, because it is an area less affected by climate change than where they are coming from. We need to be alive to those sorts of threats and movements, and to understand them, as we move forward.

Chair: You have summarised why the Committee is looking at this. There is lots to unpick in what you have just said. We will begin with Richard.

Q7 **Richard Drax:** In part, General, you have touched on my question: what is the MOD's level of ambition with regard to climate change? You have answered some of that, but is there anything else you want to expand on?

Lt Gen. Nugee: We set out three principal ambitions. First, we need to adapt our bases, our equipment, and, in certain circumstances, our training.

The second thing is that the country has a law that we must be net zero by 2050. We must play our part in that. The MOD is 50% of central Government emissions. I say "central Government" advisedly, because things such as the NHS, which dwarfs us in terms of emissions, are not part of those figures, but we have sizable emissions, and we must do what we can to reduce them without reducing military capability.

Richard Drax: That might clash with your first—

Lt Gen. Nugee: In my mind, it is clear. I personally believe that we can get to net zero, but we are not going to get to zero. We will not have electric tanks, with current technology, and we still need tanks, as has been proved in Ukraine. There is only so far that we can go. We will therefore have to make it net zero, and try to do our best to get to net zero rather than zero. We must reduce our emissions where we can.

Here I would say that there is a significant opportunity. Because so much of industry, and so much of what other people are doing, is trying to get to net zero, they are developing and innovating new technologies all the time. Those new technologies can be on our bases, in vehicles and so on. We would be foolish not to take advantage of those new technologies if they give us operational advantage. There are a number of those.

The third issue, and perhaps the one that I feel most strongly about, is that Defence's ambition is to be the global leader in understanding the security implications of climate change. The UK is often looked to as the

thought leader in this area, and we need to ensure that we remain the thought leader. When the Pentagon—President Biden and the Defence Secretary—published their strategy at the beginning of last year, it quoted only four documents, one of which was ours. They have looked to us for some thought leadership, and other countries are looking to us for thought leadership. We need to maintain that by understanding that this is a national security issue, and understanding why it is a national security issue. We need to be a global leader, and to lead the world in understanding what we can do about it.

Q8 **Richard Drax:** General, we have a lot of migrants heading this way, for reasons that we understand. I think you are predicting that that situation will get a lot worse, so do you see a role for the armed services in, for example, preventing thousands from crossing the channel, as they are currently doing? How bad will the situation get, and what role will the military have to play?

Lt Gen. Nugee: It is a very good question. Vice-President Al Gore has said consistently, including at COP26 and at COP27, that the anticipation is that there will be 1 billion climate change refugees and migrants in the world by the end of this century. That is 100 million a decade. That is an awful lot of climate migrants, and we are beginning to see it. I think it was three years ago that more people were displaced because of climate change than because of conflict.

What can the MOD do about it? What we do not want to do is what we have desperately tried not to do throughout our history: to fight on our own beaches, so to speak. I use that as an analogy. We want to stop them coming to this part of the world, if at all possible, by providing help, so that they can stay where they live and do not feel the need to move to this country. Using soft power, not hard power, the MOD can help countries that, I would suspect, invite us to. We can help countries in building resilience, in governance, and in climate change technology that we have adapted. We can ensure that those countries cope as best they can with the vicissitudes of climate change before their people move. We should try to prevent at distance—that is what our nation has done throughout our history—rather than stopping people in the channel.

Q9 **Mrs Lewell-Buck:** We are talking about 1 billion climate change refugees. Is it realistic to think that you can contain that, and build resilience in people's home countries? It is not. Every country around the world will have to take some responsibility, and take some people in, won't it?

Lt Gen. Nugee: I cannot imagine what a billion displaced people looks like. That is an eighth of the world's population moving. It is a figure that Al Gore uses, but I do not know whether it is right. Even if the actual figure is 10% of that, and 10% of those people come to the UK, that is an enormous number of people coming to the UK.

Everybody has to do what they can to ensure that those most affected by climate change are supported in their home country, rather than just waiting for them to come towards northern Europe, which, according to

the IPCC's sixth report, is one of areas least badly affected by climate change. This country is not experiencing drought on the same scale as the Sahel, or the floods that we see in Pakistan. That is because of where we physically are in the world.

Of course we will not stop everybody, but we can do our bit to try to build resilience in the countries that are most affected, using the Ministry of Defence's skills in soft power, planning and understanding of resilience; and we can do what we can to make sure that the numbers are reduced.

Q10 **Mrs Lewell-Buck:** Is that working already in the countries that you mentioned? It seems as though that ship has sailed; it is too late, and we need to look at ways to help people who will be displaced, because it seems almost impossible to stop this. Look at the examples that you have given from around the world. There is not a building of resilience, and people cannot be contained in those places. Ultimately, we will have to take some climate refugees into this country; we should be prepared for that, and I do not feel that we are.

Lt Gen. Nugee: That may be the case, but it is not an MOD decision. Surely we should do what we can to prevent very large numbers of people being displaced.

Mrs Lewell-Buck: I agree; I just think that it is failing. It is not happening. That is my point.

Lt Gen. Nugee: At the moment, people are not coming to this country in the numbers that Al Gore has suggested. People displaced by climate change are not coming here yet. The prediction is that they will come. We should do what we can to prevent that now, while we still have time, by helping them in their country, rather than just accepting that they will come to this country.

Q11 **Mr Francois:** General, a large number of those who come here at the moment are from Albania. To be clear, I take it that you are not suggesting that those people are coming here for reasons of climate change.

Lt Gen. Nugee: Absolutely not, no. I am talking about a future that is predicted and is not certain. All the evidence suggests that there will be more displaced people as a result of climate change. If we meet our goal of temperatures rising by no more than 1.5°, the effect will be uneven across the world; the same is true of a change of 2°. It is predicted that when the temperature in the Sahel is 3° to 4° higher, there will be areas of it, and of Africa more widely, where it will be physically impossible to live. People there will have to move. We should try to keep them in the local area as best we can, and should, in my view, use Defence's considerable soft power and skills to help.

Mr Francois: Thank you for that clarification.

Q12 **Dave Doogan:** What does the MOD's strategic approach to climate change identify as the key challenges? Interestingly, in your introduction,

you talked about significant sea level rises, and the effect that could have on ports, and so on the operation of the Royal Navy. Could you direct some of your response to the potential impact on the United Kingdom's domestic nuclear facilities, civilian and Defence?

Lt Gen. Nugee: I am not an expert on our nuclear facilities; I should say that first up. However, increased weather difficulties, increased storms, increased wind, and increased battering by the sea of our coastline—most of our nuclear facilities are close to the coast—may have an impact. I do not know whether they are particularly well-defended against that sort of climatic outcome. I would certainly hope so. If not, we have time to do something about it.

There are various critical national infrastructures that we need to be alive to in this country, which will be susceptible to more violent weather conditions, which is what is predicted if the globe warms by 1.5° or more.

Q13 **Dave Doogan:** On the strategic approach, in a defence context, within the climate change space, there has to be a strategy for minimising our contribution to climate change and, parallel to that, a strategy for how we mitigate the effects of the climate change that will happen—or is happening—and the weather events that that generates on defence infrastructure and operations. Is that fair—that there are two strands to this?

Lt Gen. Nugee: Yes. I think it was most beautifully expressed by a colleague of mine who said that we need to understand the impacts of climate change on defence—that is how we fight and how we operate and how we are able to adapt—as well as the impacts of potential greater conflict as a result of migration and so on as a result of climate change. The second aspect is the impact of defence on climate change. That is about emissions, sustainability, waste and a circular economy. I think we need to tackle both areas in order to really answer the question, "Are we paying attention to and are we alive to what climate change might do to both this country and the Ministry of Defence?"

Q14 **Dave Doogan:** And are we?

Lt Gen. Nugee: Yes. I think the Ministry of Defence has moved—dare I say it?—remarkably in the last two years.

Q15 **Dave Doogan:** To use your analogy from the experience that colleagues in the United States have had, the hangar roof being blown off at Coningsby—that's really unfortunate. That is going to spoil your day significantly if you are operating there. But seawater lapping into the nuclear defence depot at Coulport—that's a really big issue. Where do these threat assessments rest? Who is in charge of that matrix and understanding how we mitigate for these potential outcomes?

Lt Gen. Nugee: Obviously, we are part of Government; we are not responsible for the whole of Government, and there are other Departments that will look at how flood defences and things like that will operate for their particular responsibilities.

However, in Defence, we have a climate assessment against every single piece of infrastructure that we have. That is something we have been doing for a long time, but we are upgrading every single one of those assessments to look at what happens under a 2° scenario and under a 4° scenario, which is what the Climate Change Committee asked us to look at, to consider the impact on a piece of infrastructure and then, further, what we should do about it. We are still in the assessment phase as to what the impact will be on our infrastructure, and then we will go into what we can do about it.

Q16 **Dave Doogan:** Finally from me on this issue, you referenced your position as a non-executive and you discussed the value that is being added by a lot of your other non-executive colleagues within elements of government. Who has executive responsibility for this, in an operational sense?

Lt Gen. Nugee: You will be well aware that Defence is federated, so each of the commands has a responsibility. Each of the commands has produced a climate change and sustainability strategy, which is one down from Defence's climate change and sustainability strategy.

In the centre, we have created a department, as we said we would. It is a small department, led by a director—a civil service director—but with military support, to try to cohere and identify how we tackle climate change at a Defence level, rather than at an individual command level. Each command is looking at how they can tackle climate change in terms of both adaptation and reducing emissions.

Q17 **Dave Doogan:** How can we be assured as a Committee that the federated model that you discuss is not just the weaves on a sieve through which the whole problem will flow, with everybody having an element of responsibility but the cohering that you discussed not happening?

Lt Gen. Nugee: The strategic approach set out three epochs. That is an interesting word—I was asked to use it by the Chief of the Defence Staff at the time, General Sir Nick Carter, so I used it—but it is three eras, or phases, if you like. The first was for five years, the second was for 10 years and the third was for 15 years after that, which took us to 2050. Writing a plan for 30 years was bonkers, so actually just writing a strategic approach that covered 30 years was about as good as we could realistically do; otherwise, it just would not mean anything.

The whole intent of the first epoch was to get after the technology that already exists. That is primarily on the estate, so solar panels and things like that. Most importantly, it was to try to embed in Defence an approach around sustainability, climate change, waste and so on—including the circular economy, which was mentioned in the strategic approach—so that, for whoever was director or was responsible, there would be checks and balances within the acquisition world, the commercial world and the requirement-setting world that meant that we would take due account and take this seriously.

I am heartened that, at a recent joint requirements oversight committee, there were some quite severe questions about one piece of equipment,

which will be operating in 2050 or 2060 because of our lead times and the length of time we use our equipment. People asked, "What are the implications of climate change and of a climate-changed world in 2050 on that piece of equipment?" They asked, "What are the implications"—it was a piece of air equipment—"for fuels?" and, "Will we be able to get aviation fuel at the same price as we can today?" They were questions like that, so it is already beginning to work. We have not finished the first epoch—I think it still needs further embedding—but that is the answer to how we ensure that Defence does not drop the ball on this and the issue does not fall between the cracks: because we have built it into our processes.

Q18 **Robert Courts:** Good morning, General. Thank you for your evidence so far. The question you have just been asked was around Defence as a whole. I would like to look at each of the services and their challenges in a bit more detail. I will come on later to some of the more detailed challenges, particularly with regard to the Air Force.

I was the UK civil aviation and civil maritime Minister until relatively recently, and we always described aviation and maritime as hard to decarbonise sectors. That, of course, goes without saying. Aviation always gets seen in that way—it is, of course, very much in the public eye—but there are other things that we will be missing. Aviation makes up about two thirds of the MoD's fuel burn, for example. You have just mentioned the impact of climate change on the cooling of naval warship engines, which is something else. Could you give us an idea of some of the challenges for each of the three services, not just in terms of fuel burn and emissions, but in terms of some of the other challenges we will see through climate change?

Lt Gen. Nugee: Yes, absolutely. I will start with the Royal Navy. First of all, 59% of its emissions are through its fuel, so for anything significant to happen to the Navy's emissions, we—the world—have to find a maritime equivalent to bunker fuel that is sustainable. I coined the phrase, and it has been much misunderstood, "fast follower" in terms of what we should be doing in both the maritime industry and the aviation industry when it comes to fuel.

What I assessed, and I discussed it with the chief scientific adviser, is that we could spend our entire military R&D budget on trying to find a sustainable fuel for the maritime world and we would probably be spending 10%—if that—of what the maritime industry itself is spending on trying to find a sustainable fuel. It was the head of the Norwegian navy who turned round to me and said, "There is no point in us designing a fuel today if the UK doesn't have it, because we are not going to be able to refuel." Navies are intrinsically collaborative in what they use for things like fuel, unless you want your own depots all the way around the world, and none of the navies—perhaps with the exception of the US navy—is big enough to do that. We need to collaborate, and there is no point in just collaborating as militaries, because that would still cause us problems; we need to collaborate with industry.

The concept of fast follower was to be really up with the hunt with industry, but to let industry take the lead. For some industry, it is existential; for us, it is not. We will find a way, because we will need a Royal Navy as long as there is water in the sea. For me, there is a piece here about, "We've got to find a fuel, but we are not going to be the lead in that"—but there are other areas that the Royal Navy will have to deal with.

Q19 **Robert Courts:** Just to pick up that point, I totally understand the force in what you are saying there: the Navy will understandably piggyback on and stand on the shoulders of the work that is being done in the civil sector. That makes perfect sense, but are there operational requirements that will overlay that for the Navy, for example?

When we are looking at the different kinds of fuels there may be, electric batteries may work for small ships—very small boats—but, clearly, if you are looking at a cruise ship, a container ship or perhaps an aircraft carrier, electric will not work for that. You are looking at something else. In the Navy, are we looking at small modular nuclear reactors? Are we looking at a different form of hydrogen, or at ammonia? What operational constraints are you going to see overlaid on that?

Lt Gen. Nugee: You would have to ask the Navy for the detail of what they are looking for. What I would suggest is that there has been talk—I do not know how much further it has gone than talk—of small modular nuclear reactors to act as a mothership for small, remote-controlled, semi-autonomous vessels: minehunters might come to mind. The Defence Science and Technology Laboratory has already created, I think, an 11 or 12-metre vessel that is semi-autonomous and can carry a fairly significant payload. There are opportunities for alternative fuels that do not mean that every single ship has to have the same type of fuel, and I think that is the big difference. It is exactly the same in the aviation world.

Q20 **Robert Courts:** Of course, that has a bunkering ramification, doesn't it?

Lt Gen. Nugee: It depends on what the alternative fuels are. If the alternative fuels are hydrogen or electricity, there are other ways of generating that that do not necessarily rely on bunkering, and then there are synthetic fuels, but I do not know where the maritime industry has got to yet. I know there are lots of alternatives out there, ammonia being one of them, but I do not think they have settled as an industry on what—

Q21 **Robert Courts:** No, they certainly haven't, General; I agree with that entirely. All I am getting at is whether there is anything that you would rule out. Is there something that the civil world might find is—

Lt Gen. Nugee: I do not think so, because we have to be able to take fuel from wherever it comes from. That is the nature of the Navy.

In the aviation world, 77% of their emissions are through their fuel, and therefore there is an opportunity there. The RAF have been very proactive in becoming part of the Jet Zero Council, and are looking actively at what sorts of fuels they can use. That includes biofuels as a sustainable aviation fuel—only last week or the week before, for the first time ever, a Royal Air

Force Voyager flew with 100% sustainable aviation fuel—whether that is biofuels created from algae or from crops. At RAF Brize Norton, they have an experiment looking at using algae to create sustainable aviation fuel. I heard at COP that there is a company that aims to create millions of gallons of sustainable aviation fuel from algae. That sort of thing is possible, and we have the protocols in place already to be able to sustain 50% sustainable aviation fuel in our aircraft.

The Navy's other challenge, and what it is desperately trying to do, is to make His Majesty's naval bases more sustainable. Devonport has the most fantastic heat and electricity generator, which is an incinerator. It has very high standards of emissions, and it is taking all the local waste—civil waste—from the area. It has reduced the amount of ground-dumped waste (landfill) by 98%, and it is now powering Devonport with all its heat and electricity. That sort of thing is where the Navy is going.

In the Army, it is all about the estate. Some 60% or 65% of its emissions are from the estate—the Army has a huge number of buildings on the estate; there is a big training estate—so how can we make our buildings more environmentally sustainable? How can we build new buildings? We are building zero emission buildings already. How can we insulate our buildings and make them more acceptable so they reduce their emissions? How can we make the land more susceptible to sequester?

Q22 **Robert Courts:** Thank you. I will come back in a little while to some of the areas where we can look at some of the detail on where Defence can reduce its emissions, but I am keen to double back on this question a bit. Are there any extra challenges faced by any of the three services, rather than just the emission-cutting one? I will come back to that in a bit.

Lt Gen. Nugee: In a sense, because fuel is such a big part of it, that is the main focus. But what we are trying to do is use emerging technology to make us more self-sufficient. That is a challenge because the technology is not quite there yet. For example, the technology for monobore closed-loop geothermal is developing; that is something that we can try to develop. The technology is developing for electric drives on some of our vehicles—not electric vehicles but electric drives—which makes them much better vehicles off-road. The main challenges are to do with fuel, but there are other challenges. For example, the Department is wasting money in terms of recycling stuff; we ought to be recycling some of the materials that we could recycle. So there are opportunities as well.

Q23 **Chair:** Could you give us an example of that?

Lt Gen. Nugee: If the clothes that we wear are not worn out, then they are returned.

Chair: Uniforms?

Lt Gen. Nugee: Yes. We could recycle some of those uniforms more effectively that we are doing at the moment, for example.

There are myriad challenges in terms of emissions, and in the fact that we have equipment that is still going to be around in 2030 or 2040 that was not built to specifications for reducing emissions. We have myriad challenges in terms of some of the materials that we are using, because we have always used those materials. I see these as opportunities rather than challenges, because the new technologies that are coming online, although they are not quite there yet in many cases, offer us an opportunity to use a less expensive material in terms of both carbon and cost, which will benefit us and have better capabilities.

Q24 **Robert Courts:** May I raise one more point? Going back to the point on fuel and the lead time of development, if you are dealing with something like Tempest, for example, then clearly power plants are still very much being considered at the moment, and you have the time to think about that. However, if other aspects—I am thinking about things like Type 31, for example—are going to be developed and built over the course of the next five to 10 years, and be in service for 20 or 30 years, or potentially after that, then it is the same challenge that the civil sector has. Presumably, it makes meeting net zero by 2050 much harder, because you have to install now the technology that you will need to be in service by 2050. Does that not present a significant challenge for defence, simply because of the long lead time and then the long service time for some of the kit that you will be using?

Lt Gen. Nugee: I was always taught that you have two things: fitted for and fitted with. Particularly in the Navy, vessels were fitted for certain missiles, and only when they went to war were they fitted with those missiles. That is an example. It is a really difficult challenge. What DE&S and the Navy are grappling with is how to fit for the future when they are fitting with the current technology, and the agility to be able to do that. We are not going to change the aircraft carriers' engines. In my personal view, that would be a ridiculous amount of money for something that is not going to give material gain in terms of operational capability, and that should be our guideline.

From my perspective, if we can build the Type 31s and the new destroyers in a way that when new technology is available—either as an add-on or as a replacement fuel—we can take advantage of it, then that is what we should be doing. We should be building with this in mind. This is difficult; I get that. When you are designing a ship, the first thing you do is design the engine. The Navy laughed at me, and rightly so, when I said to them, "What I want you to do is design the engine last. Design an engine hall—design the power output of the engine—but leave the actual design of the engine right until the last minute." But that is not how we design ships; we design ships with the engine first, because everything is built around the engine, and it is the same with aircraft. What I was asking for is probably impossible.

The next best thing is to have an eye to the future, to understand where the future is going. Being a fast follower requires a really good horizon-scanning capability, almost like a partnership with industry. When the

industry settles on a particular fuel, we need to have the capability to change our engines' capability without changing the engines themselves.

Q25 **Robert Courts:** It does mean that there is likely to be a need for multiple fuels, though. You are likely to need, from both a maritime and an aviation perspective, a sustainable fuel to drop into existing technologies before you start looking at the next generation. Be it for naval, nuclear, ammonia-hydrogen or whatever it may be, it is going to be very staged, isn't it?

Lt Gen. Nugee: I think it is going to have to be. In my view, there is no way that defence forces can be zero carbon under the current technology constraints. The best we can do is get as far as we can towards net zero.

Chair: Net zero. Thank you.

Q26 **Gavin Robinson:** Good morning. General, you have been very helpful in setting out some of the multifaceted challenges around climate change for defence, national security and the defence of our nation. If we set those aside for a moment and just look at the circular economy and the sustainability part of what you are doing within the Ministry of Defence, how do you feel that compares with other Government Departments in Whitehall?

Lt Gen. Nugee: We are under the same set of greenhouse gas targets as other Government Departments. We have to meet the same stipulations as other Government Departments, so I would say that we are doing as well as other Government Departments.

Q27 **Gavin Robinson:** Being under the same target does not mean you are doing as well as other Departments.

Lt Gen. Nugee: You are absolutely right, and you are correct to pick me up on that. We have exceeded some of the targets that we have been set, and we are finding some more difficult to meet, but on the whole I think you will probably find the same is true for all Government Departments. To put that into perspective, we have reduced our emissions by 54% since 2010. That is better than most equivalent Ministries of Defence across the world, and it is a reasonably good figure—it is not far enough, of course, but it is reasonably good. In terms of waste and greenhouse gas emission targets, we exceeded the reduction in things like business travel, but we did not exceed things like use of water.

Q28 **Gavin Robinson:** You have been appointed in this role; you are the non-executive director tasked with this function and you have three services operating beneath you, but you are part of the co-ordination role within the Ministry of Defence. Are there similar types of structures across Whitehall? Are you following a model in the Ministry of Defence, or are you doing something unique within the Ministry of Defence?

Lt Gen. Nugee: I am one of a number of non-executive directors. Non-executive directors have been appointed in other Government Departments. I think I was the first non-executive director in Defence for climate change and sustainability—in fact, I know I am—and other

Government Departments have followed suit with non-executive directors whose whole responsibility in their Departments is climate change and sustainability.

In terms of other Government Departments having a directorate, other Government Departments are not quite as federated as we are, and they are not as large as we are. The Ministry of Justice is a really good example, and we have taken a lot of advice from the Ministry of Justice over time. They set up a directorate, they set up a champion, and they set up a senior responsible owner for this, similar to what we have done. I do not believe that all Government Departments have done that, but we have taken best practice—in this case, from the Ministry of Justice.

Q29 **Gavin Robinson:** I guess the other side of the comparative analysis is with other Defence Ministries. You have helpfully mentioned the 54% reduction in emissions since 2010. That compares favourably with other Ministries of Defence across the world. You also mentioned in response to questions from Mr Drax, I think, that we are world leading in the thinking about some of these issues. Are there any Ministries of Defence or armies internationally that we look to and take lessons from?

Lt Gen. Nugee: I think it is a case of different things from different countries. I shall give some examples. The French, who have just published or are about to publish their equivalent of our strategy, had the idea two years ago of creating a sustainable deployed base. We took some of their ideas and have translated that into what I think is a very exciting programme for sustainability on deployed bases, which Strategic Command is looking at. The Americans have gone down two routes. One route is to protect their bases from the sorts of weather conditions that pertain. You can understand why, given that they have been so badly affected by them. The other thing they have done is, in their army, looked at significant electrification. We have teamed up with them—as best practice, if you like—and we are working in co-ordination with them to look at electrification. If you look at the Canadians, they are about to take on the role of hosting what is called CASCOE, which is the Climate Change and Security Centre of Excellence for NATO. We are very closely linked with them. It will be a NATO base, effectively, but we're very closely related in order to understand the national security implications. They came and spoke at our recent Oxford University and Centre for Historical Analysis and Conflict Conference on climate change and security particularly.

A number of countries are involved in this work. The Netherlands have a particular interest in things like sustainable food and vertical farming, where they are probably the world experts at the moment, and they have gone down a hydrogen route for some of their vehicles. We are looking at what they have done and working out whether that is applicable to us. What we are trying to do is to take best practice from everybody and co-ordinate it into a coherent best-practice approach.

Q30 **Chair:** May I draw two aspects of Robert's questions and Gavin's together and explore what more the MoD is doing to harness small nuclear

reactors—micro reactors and modular reactors—from a security perspective. If you go to a garrison in Kandahar, for example, there is the ability to have an ISO container dropped off in a secure environment, plugged into the grid and providing very clean energy. Is that something that the MoD is looking at or exploring?

Lt Gen. Nugee: Absolutely. The Secretary of State asked me to go to Rolls-Royce on his behalf to look at the small modular reactors about a year ago, and I know that others have gone to look at that more recently. I don't want to be quoted on this particularly, because I will probably get the date wrong and it is far more important that they tell you, but Rolls-Royce were looking towards the end of this decade to be able to produce that. They wanted to know whether it was of interest to the MoD, and the answer, certainly a year ago when I went for the Secretary of State, was, "Yes, we are interested," because a small modular reactor in a 40-foot container will produce 5 MW for five years, without refuelling. If we can achieve that, that is very significant power at a deployed base that will be far cheaper, in terms of both treasure and blood, than very sophisticated and extensive combat logistic patrols, which we produced to go to Helmand.

There is another side to that. We should not forget that the most senior British Army officer killed in Afghanistan was on a combat logistic patrol and was an infantry battlegroup commander, because the infantry was protecting—

Chair: Who was that?

Lt Gen. Nugee: He was in the Welsh Guards. Forgive me, but I cannot remember his name. He was using his infantry to protect that logistic patrol. If, therefore, you have fewer logistic patrols because you have a source of energy on the deployed base that is guaranteed—a small modular reactor would do that—you can use that infantry for what it is designed for, which is, if you like, to take the fight to the King's enemies. So from my perspective this is a win-win-win, if we can make it work. Certainly the MoD was very interested, and I am sure it still is.

Q31 **Chair:** I will push this a bit further again. I have done some work myself, because from a security perspective it seems to be a no-brainer. Say you have an Astute class submarine, which already has a nuclear reactor in the back, and imagine that parking up in Plymouth or Portsmouth and plugging into the grid. Fantastic—we have power. The invention is already there. My question is why has it been so slow in getting approval for us to advance what is in fact a new invention, but something that is based on something else. It is taking years to do this. I wonder whether you could help the Government to expedite small modular and micro reactors before we get beaten by Westinghouse and, indeed, Chinese capabilities as well.

Lt Gen. Nugee: I am not sure that I have any influence on whether the Government could do that. I would argue that the MoD could by showing interest and making the case, both in terms of cost and lost military capability—because it is on combat logistic patrols—and in terms of people

killed. The US assessment is that 2,000 to 3,000 soldiers were killed on combat logistic patrols in Iraq and Afghanistan. We had a number killed on the combat logistic patrols. If we can reduce those—and modular nuclear is a way of doing that—

Q32 **Chair:** To explain that in layman's terms, the reason they were killed is that they were bringing in fuel and supplies on routes that were vulnerable; that is why they were attacked. If you are able to produce your own energy with one delivery, the necessity for those patrols goes away.

Lt Gen. Nugee: It reduces. If you can produce your own water or a significant proportion of it, your own fuel, to a degree your own food—although I am not sure that vertical farming is quite there yet—or 3D print some of your spare parts, all of that reduces the combat logistic patrols that are needed. That therefore reduces the vulnerability of our soldiers but, more importantly, allows them to go and fight.

Q33 **Chair:** Away from this topic—I beg the Committee's indulgence—I had an Adjournment debate on the very subject of small nuclear reactors. It is clear that the designs from Rolls-Royce have gone to the Treasury and are waiting for approval. The Treasury has come back and said, "We cannot allow this to go further and approve it unless we have a cost comparator." So if somebody else invents the same thing and it can then do a comparison of the prices, it will then allow Rolls-Royce to go forward. It is mad. I underline this because you will be a customer, if you like, for small modular and micro reactors, and could nudge the Government forward. It seems crazy that we have Rolls-Royce, which has the know-how, being held back while our competitors are catching up with us.

Lt Gen. Nugee: I will add one comment. The US made an assessment—I cannot quote where it is written down, forgive me—that a gallon of diesel, or 4.5 litres, costs $500 to get to Kabul. If you put the cost of diesel at $500 for 4.5 litres, or over $100 a litre—by US standards, that is unbelievably expensive, as it is for us—a small modular nuclear reactor will actually physically come in cheaper than that for the equivalent power ratio. It is therefore not just about military capability, which should be our top priority, or the number of people killed on those logistic patrols; it is about cost as well.

Q34 **Chair:** That is a very powerful argument indeed. You mentioned the United States. The stated goal of the United States army is to achieve a 50% reduction in its greenhouse emissions by 2030—compared with 2005, I should say, rather than pre-industrial levels. It will reach net zero by 2050. Does the British Army have any such commitments?

Lt Gen. Nugee: The British Army has not, to my knowledge, stated that it will be net zero by 2050. The RAF has stated that its intent is to be net zero by 2040, and the Navy has stated that its intent is to be net zero by 2050. We need to be completely clear that in all three cases, and I am sure in the US case as well, that is dependent on viable and economically viable technologies coming forward that allow us to get at the fuel issue, which is over 50% of the MoD's problem. Without physically and

economically viable fuels—there are an awful lot of things that need to happen before that takes place—that will be very difficult. Personally, I believe we can get to net zero. We should certainly work towards getting to it at every opportunity.

Chair: That is very helpful. Thanks very much indeed.

Robert Courts: I would like to pick up a couple of those points in a bit more detail. In the questions I will ask over the next few minutes, I want to explore where across defence we can most effectively cut emissions. I have two examples that I would like to look at. The first is aviation and the second is housing, and then we can talk about anything else you want to add on that.

On aviation, I should say that I represent Brize Norton, which is in my constituency, so I am quite familiar with it. I set up the Jet Zero Council with the then Secretary of State for Transport when I was at DfT, so I am coming at it from those joint constituency and professional points of view. You quite rightly mentioned that there is a lot of work going on. I know that RAF Marham has done a lot of good work, and you may wish to address that. I think it has a biogas plant, which is providing about 95% of its fuel. Regarding Brize Norton, you mentioned my constituent Corporal Woodhall's idea for breaking down aircraft oil, which is obviously a world-leading idea. They have got their cargo idea too, involving autonomous travel, and then you referred to solar farms.

I want to concentrate on sustainable aviation fuels. You are quite right that the Voyager flew on Friday. It is the first time that an aircraft of that size, civil or military, has flown with 100% sustainable aviation fuel. I understand what you said about working in collaboration with the civil sector and being a thoughtful follower, as it were, but defence clearly has its own requirements for fuels. This has been billed as a cooking oil-powered flight. Clearly, there are a lot of other technologies out there involving municipal waste, human waste and carbon capture. Is the Air Force or the MoD more widely looking at any of them to ensure that they have their own safe supply? I am mindful of the cost point that you have made.

Chair: I really apologise, but is it okay if you just hold that thought? Emma has to depart. Robert, is that okay? You built up an introduction to an important question, but can we let Emma get in?

Robert Courts: Of course. I'll do it again and I'll add to it next time.

Q35 **Mrs Lewell-Buck:** Thank you very much. I might bounce around a bit here because my two questions are on separate topics. Can you please explain to us whether the Department is using any of the large defence estate to tackle biodiversity loss and generate renewable energy? If so, what is it doing?

Lt Gen. Nugee: Yes. We are obviously subject to the same rules as everybody else that DEFRA has brought in for biodiversity loss, but we are particularly trying to build our peat bogs and make sure we re-wet our

peat. We have quite a large peat bog area on our estate. A third of the MoD land is tenant farmed, and we are looking at what we can do with tenant farmers to ensure both that they retain their livelihoods, which is obviously important for them, and that we increase the biodiversity within our land.

There are certain limitations. The biodiversity on Salisbury Plain is exceptional because there has been no human habitation of the centre of Salisbury Plain for 150 years at least, because it is a training area. What we don't want to do is plant trees all over Salisbury Plain, not only because it would be appalling for training—it is primarily used for training—but because it would be very detrimental to the chalk down.

We are looking to plant more trees. We are part of the nation's approach to plant the thousands of hectares of trees that we need in this country. We are playing our part where it is applicable and appropriate for our training. I will give you one other example. Sennybridge is a training area in Wales, and for 30 years we have been draining it. That has allowed water to run off so it has dried the training area, which makes it easier to do a particular style of training that the infantry were doing. What it also does, in the very hot weather that we had this year and over the last 10 years, is make it much more susceptible to fires, so we have lost some training time because it has caught fire. To keep the fires down we have put sheep on the training area, which means that we cannot use it for training people. So draining it, while better in the environment of 10 or 20 years ago, is not necessarily the right answer. If we reverse that—I am just using this example—not only will we have less run-off, but we will have more natural biodiversity. A slightly wetter training area will make it more difficult for the infantry, I accept, but it will allow more natural biodiversity in the Sennybridge training area and it will not catch fire as often, and so we will be able to train more often.

There is a sort of symbiosis here of what is good for training, which is why we have responsibility for this estate in the UK. If we did not need it, we would get rid of it. What we have for training is optimised for training, at the same time as trying to improve our biodiversity. We are doing a lot of that.

Q36 **Mrs Lewell-Buck:** Did you say at the start, General, that you had the same targets as the Department?

Lt Gen. Nugee: We work under the same biodiversity rules as DEFRA for our estate. In terms of renewable energy, the Army, for example, is in the process of putting up 80 solar farms under project Prometheus. The idea of that is to make our bases self-sustainable in energy and therefore more resilient. There is a by-product of that—you may laugh that I call it a by-product—which is significantly less emissions. But the point is about resilience. It is about building the resilience of our bases. It is about making sure that, should the grid fail because the amount of electricity required in this country is greater than our ability to create it, the Army do not have that problem because they have got their own bases.

As I mentioned earlier, there is closed-loop monobore geothermal, which is a new technology coming along the line. That could provide some of the answer. There are different boilers coming online. There are air source heat pumps. There are brand-new requirements on how we build our buildings in order to try to reduce emissions. We are using our estate as best we can, both for biodiversity and for training, and to generate electricity and to make sure that we use less electricity because we have more sophisticated buildings.

Chair: Thank you very much for allowing Emma to step in. Back to you, Robert.

Q37 **Robert Courts:** I have given a couple of examples that I know of work on-station at RAF Brize Norton and at RAF Marham with regards to reducing emissions on-station. Is there anything else that you would like to add to those examples that I am aware off? Leave fuels aside—I will come to that in a second.

Lt Gen. Nugee: The RAF have a programme called RAFX and a project called project ViTAL in co-ordination with Newcastle University, which has six projects that are looking at how we can improve our approach to climate change and sustainability in the RAF: carbon accounting, and a completely different type of solar, for instance. I will be crucified, probably, by the scientists, but it is a sort of acetate-type material, so you can just roll it out. As I understand it, the RAF wanted to put solar panels on all the hangar roofs, but many of the hangar roofs were not structurally strong enough to take solar panels. If we had an acetate solar panel that is thin and you can roll out, that will obviously not be as efficient, but it will produce some solar energy, which will be able to produce electricity. Then you can put them on all the roofs. They are looking at that.

Q38 **Robert Courts:** Is there any operational downside to doing that? I am conscious that solar panels are reflective. Is there any operational impediment to doing that?

Lt Gen. Nugee: You would have to ask Newcastle, but I do not think we are not far enough ahead in the project to be able to judge that yet, so I do not know. It would be part of the consideration, obviously. But if you do not look at these things, you will never find out.

They are also looking at geothermal and life cycles. This is quite important. How do you build life cycle into our equipment base, thinking about life cycle costs as opposed to just upfront cost? For example, a lot of renewable energy has quite a high capital cost, but the life-cycle cost over time is much less. Certainly solar panels have been proven to pay back quite quickly, particularly given the cost of gas at the moment.

Looking at how you can bring that concept of life-cycle costs into our acquisition, for example, is something that the RAF is also looking at: can we put a life cycle on RAF equipment? It is also looking at fuels for what it calls the yellow fleet. I have heard of one particular company that uses the methane from farms, turns it into liquid methane and powers the tractors that cut the grass, which is part of the methane creation, at Newquay

airport. It uses methane for the tractors—a beautiful circular position. I think the RAF is looking at that to see whether it could apply to us.

Q39 **Robert Courts:** May I look again at sustainable aviation fuels, or SAF? You are quite right: the Voyager flew from Brize Norton on Friday; it was the first time that a 100% SAF-powered aircraft of that size, civil or military, has flown. That is a very welcome step, and clearly everybody is very much to be congratulated for making it happen. I want to look at what the next step is. The Jet Zero Council looks to have net zero transatlantic flight by 2050, and net zero domestic aviation by 2040. The Royal Air Force has said that it wants to be net zero by 2040—a more ambitious target than civil aviation has for transatlantic flight.

The reason I focus on that is that, from an RAF perspective, it makes the transition even more of an imperative. Sustainable aviation fuels are currently more expensive than regular fuels. That is one of the barriers to their adoption. There is, of course, an issue of supply and demand there. With regard to sustainable aviation fuels, is the MOD putting any pressure on the Treasury to adopt some of the price stability mechanisms that the civil aviation world wants to see?

Lt Gen. Nugee: The simple answer is that I don't know. The barrier to sustainable aviation fuels, as you have rightly pointed out, is cost. It is not the technology. It is the cost of delivering, which is largely down to the paucity of renewable energy. To create sustainable aviation fuel, green energy has to be used. If it is not green energy, you might as well just use the fuel that creates the fuel, if you see what I mean. This will take time, because we need sufficient green energy to deliver sustainable aviation fuel. I do not know whether the MOD is putting pressure on the Treasury; I do know that the RAF is extremely keen. It has to have sustainable aviation fuel as part of its mix—or, if not, as the whole of its mix—by 2040 to meet its net zero target.

Q40 **Robert Courts:** Perhaps that is something I can leave you to consider. The economic side of it must clearly be addressed in some way, and there are lessons to be learned from some of the wider transition work, for example with offshore wind farms. You are right in drawing attention to the feed stock, or what the sustainable fuel is. In the Jet Zero Council, we said that it won't be crop use, and that will probably be the same for defence. The media has reported the flight that flew on Friday as having been powered by cooking oil, which is one of a number of options.

I am conscious that the Air Force will need its own supply, for operational reasons. It will also need it earlier than commercial aviation. Is a favourite emerging? We saw the Air BP cooking oil solution on Friday, but there are many others out there. Until we understand which of those is the best and most promising fuel source, it is difficult for us to address the supply and demand point, and therefore the cost point.

Lt Gen. Nugee: I completely agree. It is exactly the same, as I was saying, in the maritime environment. Industry will make some decisions, and has to make some decisions. A plane flying from A to B will need to refuel at both ends, and, apart from with domestic flights, it will be

refuelling in different countries. We therefore need consistency across the aviation industry, so that we can produce the right type of sustainable aviation fuel. It would be much more difficult, and probably in the end much more expensive, if the Royal Air Force chose a fuel that was different from that chosen in the civil aviation environment.

Interestingly, the Royal Air Force, under Sir Mike Wigston, has set up what is called the GAFCCC—the Global Air Forces Climate Change Collaboration—which is a meeting of the 28 major countries with air forces to work out how to do all this. You have a consistency across air forces—that's the whole idea of the GAFCCC. They meet a number of times a year to try to make sure that they are working in lockstep with each other, but, in my view, that has to be in lockstep with the civil aviation world as well. I don't think there is a favourite yet. I would be surprised if there's a favourite if the Civil Aviation Authority hasn't chosen a favourite. This makes it more difficult for the defence fuels strategy, which has just been rewritten in order to be able to accommodate sustainable aviation fuel, some form of sustainable maritime fuel and some sort of sustainable land fuel. Ultimately, we are almost definitely going to need some form of sustainable land fuel for things like tanks.

Q41 **Robert Courts:** As much as I would love to spend the rest of the session really getting into the detail of that, I have one other question I'd like to ask, and I am conscious that others will want to come in. I want to talk about housing as an opportunity to save emissions, which, as you rightly said, is a big part of the Army's thinking—it will be the same for the Air Force as well. What is being done around insulation and retrofitting with greener technologies to reduce emissions from the housing stock?

Lt Gen. Nugee: Most of our housing stock—I can say this as ex-Chief of Defence People—was built before 1970. In fact, the majority of our housing stock was built between the '50s and the '70s, which was probably the worst time for building houses in this country because we were still broke from the second world war, and so we built them very cheaply. A lot of the MoD housing, sadly, was never built to a very high standard, because we couldn't afford it when the houses were being built between the '50s and the '70s. We have this legacy of buildings. I was advised, as Chief of Defence People, that they were meant to last no more than 50 years and that we should be knocking them down and starting again after 50 years. That, of course, doesn't happen very often in the real world.

What we are doing on housing is that all our new accommodation is being built to completely different standards, which are very heavily insulated and try to be, if not are, net zero, or what I would call net negative—they are giving back more than they take from the grid in order to heat and light. We already have examples of that. We don't build a huge amount every year, but as we build more and get rid of old stock that is not very high quality, we are making them emission, heat and electricity-efficient so that we are actually giving more back to the grid than we take.

That is one answer. The other is that the MoD, through our contractors, is looking at novel technologies to try to heat and light our buildings in a way that is net emission free. Whether that is electric heating, heat pumps or geothermal—whatever the methods are, the MoD is looking at them to try to reduce the emissions on the estate. It is absolutely top of the agenda. It is a question of making sure that the technologies are mature enough and making sure that they are financially viable.

Q42 **Richard Drax:** Lieutenant General, I think you have answered part of this question, but let me ask it anyway and see what you have to say. As well as looking to achieve a 50% reduction in greenhouse gas emissions by 2030 and reaching a net zero position by 2050, the US army has also set itself the task of proactively considering "the security implications of climate change in strategy, planning, acquisition, supply chain, and programming documents and processes." Should the MoD be doing that?

Lt Gen. Nugee: I can't speak for the targets, but I can speak for the approach, which actually comes from us, I would argue, which is absolutely to build it into the DNA of the Department so that the Department has to consider the emissions, waste, sustainability and circular economy outcomes of its future emissions.

Where I think we can learn from the US Department of Defence is that they have been very clear that every combatant commander must run a wargame that includes climate change. Some of those will end up as, "What do you do once climate change has created a situation?" That will be humanitarian assistance and disaster relief, and how you do that. That is how some of the combatant commanders are apparently looking at it. Others are looking at, "How do we prevent climate change affecting our ability to run operations in this particular area?" So, for example, in Africa, AfriCom is looking at that. I think we can learn something from the concept of war gaming.

Interestingly, think tanks in NATO and Europe are looking at this; the Hague Centre for Strategic Studies just ran a wargame looking at what the imperatives are to try and reach net zero at the same time as ensuring that capability is improved. These things are beginning to happen, and I believe there is an opportunity here for the UK MoD to do something similar and build climate change scenarios and environments into the wargames we run, to ensure we are not caught on the hop.

Q43 **Richard Drax:** Are we doing this war gaming?

Lt Gen. Nugee: The MoD is doing some war gaming. I think there is more that could be done. The MoD is doing some war gaming of climate change, but I think we could learn from our US colleagues on how to do it. They have put aside, I think—I will have to get the figure—$15 million to aid climate change becoming part of the scenario setting, which is not a lot in US defence budget terms.

Richard Drax: It is in ours, though.

Chair: David wanted to come back on something that Richard was

covering.

Q44 **Dave Doogan:** In terms of Defence accommodation, all of us on this Committee, and many parliamentarians, are familiar with the challenges that the Department has in its standard of accommodation. Many people are paying next to no rent, or no rent at all, because the standard is so poor. There is a huge legacy issue there, just in terms of weatherproofing those properties, much less the comfort of the occupants—and much less the energy efficiency of those properties. Ground-source heat pumps, air-source heat pumps and widespread solar PV installations are massive capital costs for Defence estates. Do you see economies of scale that can be achieved by consolidating into a much smaller footprint with a much higher quality of accommodation?

Lt Gen. Nugee: It is not really for me to say from a climate change perspective whether the MoD should have a different physical footprint on the ground. There are very good reasons for consolidating, and there is a very good reason for having a more resilient structure, which is that it is slightly more dispersed. To take it to an extreme, if the whole of the Defence estate was in a single space, all our enemies need to do is take that space out and we have lost our entire defence infrastructure. Although that is absurdly reductive.

We must do what we can to improve the quality of our quarters for our people—I have had that mantra for the last six years. One aspect of that is making them better insulated, more efficient to use and giving them an electricity and heat supply that is much cheaper, after the initial capital outlay. You are right that this costs money. That is the problem with a lot of the renewable energy environment; it costs more capital upfront.

Q45 **Dave Doogan:** I was just at a housing association in my constituency with heat pumps on each house—they are 30 grand a pop.

Lt Gen. Nugee: Heat pumps are well subsidised—or they were well subsidised. There are other alternatives coming online, and the technology is developing so that you do not have to go to a heat pump. But there is a significant capital outlay.

I had a discussion with the Treasury, two years ago, when I turned around and asked, "If you have got two solutions, and one is slightly more expensive but has less carbon, and one is slightly cheaper but has more carbon embedded and in use, would you allow us to go for the slightly more expensive option?" The Treasury said yes, it would be delighted. I then went to the director general of finance of the MoD—this is while I was still serving—and said, "What would your answer be?" and he said, "Well, the expensive is still more expensive."

We need to understand the implications. It goes back to the point about whole-life cost. If we can see that there is a return on investment, and if we can invest to save rather than just taking the capital cost as the only consideration, then provided the money is there and can be prioritised, we will be much better off as a result doing this, in terms of the quality of housing for our people, but also in terms of cost. The MoD is absolutely

looking at this, but there is a straight constraint, which is that the Defence budget is finite.

Q46 **Chair:** My question is about how the UK's armed forces are adapting, and you answered this very well in your opening remarks. You mentioned that you are trying to change the whole design of bases so that they are more climate change friendly. Does that also apply to Gibraltar, Cyprus, BATUK in Kenya and our other bases around the world—HMS Jufair, for example?

Lt Gen. Nugee: In places, yes, absolutely. Take Cyprus, for example. Cyprus would be a fantastic place to have lots and lots of solar panels, but it is inevitably complex. Most of our electricity for the sovereign base areas in Cyprus comes from the Republic of Cyprus. We do not create our own electricity. If we were to create our own electricity in that area, it would be really easy with the amount of sun you get in Cyprus—so much so that the Met Office predicted that by 2040-odd, the heat of the training areas would be beyond the limits that we are currently allowed to use for training, which would effectively make Cyprus unable to be trained in for certain months of the year. That is in the future—it is not now—but it suggests that we have a lot of solar power potential in Cyprus. That would alter the relationship with the Republic of Cyprus, so we need to understand that and work through that.

We are looking at Cyprus, and we are looking at wind in the Falkland Islands, which there is lots and lots of. Are there areas where the MoD can use its overseas bases and come up with a solution for it that is different from the current solution and will engender renewable electricity and therefore be cheaper in the long run?

Q47 **Chair:** You may not know this, but maybe you can write to the Committee: how is the power generated at the Port Stanley base in the Falklands? How does the Falklands itself get its fuel? I am guessing there are tankers; I am not sure that there is any indigenous supply. Given what you just said, my next question is: how many wind turbines are up and running now? The last time I went was a few years ago, and I did not see any.

Lt Gen. Nugee: I went a few years ago, and I do not believe there were any there then. I am talking about potential, rather than actuality. As I understand it, Strategic Command, who are in charge of overseas bases, are looking at how to reduce the cost to our overseas bases of energy. I do not know how power is generated in Port Stanley or in Mount Pleasant.[1]

Chair: When I was down there, they were spending a lot of time looking for prospective oil around the Falklands, but it all might come a little bit too late.

Q48 **Robert Courts:** You have touched on some of the operational benefits there may be of net zero steps so far, such as cutting down the cost of

[1] Since 2021, there have been in excess of 100 SD3 wind turbines – a small system suited for remote locations – operating on the Falkland Islands. This meets over 85% of the Islands' domestic energy requirements, including for the civilian population.

transporting diesel generators around, but there may be other things like silent operational running for electric vehicles. Can we look for a moment at some of the opportunities, rather than the challenges, which we have spent most of the time talking about?

Lt Gen. Nugee: All three services have opportunities, but if I focus on the Army and the ground base to start with, I think there are opportunities in terms of our own energy supply to our home bases—we have talked a lot about that—and matching supply and demand through micro-grids. Rolls-Royce is looking at that very closely, but it is not the only one by any manner of means looking at micro-grids. The whole idea is to try to balance supply and demand in a much more efficient way than we do at the moment.

At the defence equipment and support exhibition, the DSEI, last year, I was shown a diesel generator that has solar panels and a micro-grid system attached, and it was 70% more efficient in terms of the amount of diesel that it used for the same amount of power. So there are opportunities there.

There are opportunities in terms of water generation. The Massachusetts Institute of Technology has just created, for example, a portable desalinator, which is a first. It is not on the market yet, but there is that sort of thing. There is a company in Holland called Upfall, which recycles 90% of the water that you use in a shower.

Chair: Sorry, can I go back? How is the desalinator powered?

Lt Gen. Nugee: Through renewable energy, but I do not know much more about it because it is not yet in production. The idea is that it is through renewable energy. As I say, you also have the recycling of water in showers. It recycles 90% of the water and it goes round so fast that you do not lose the heat that was in the shower in the first place, and therefore it costs less to heat the water as well as using less water.

There are lots of opportunities for making our lives more effective as soldiers because you are reducing the amount of combat disenchantment and becoming more self-sufficient. There is the potential for vertical farming. I think that is a little way off, to be absolutely honest. Personally, I do not think the technology is really there yet. So that is in terms of sustainable basis.

When you look at recycling opportunities and the circular economy, there is a way of saving money for the MoD by recycling some of what we currently dispose of. The MoD could think in different terms, which it is doing, in terms of a circular economy, including recycling heavy bits of kit. We have recycled frigates for a very long time very successfully. This is off the top of my head, but I think 92% of a frigate is recycled—something like that. That is extraordinary, and we have been doing that for a number of years. There is an office in Portsmouth that does that.

You can think about all the things that we use. We have recycled brass on our ranges for a very long time—we always pick up the brass at the end of

a training exercise so that it can be recycled—but now we are looking at the cardboard that is used to hold the ammunition as you go on the ranges. It is about looking at every single material and thinking, "Can we recycle that? Can we use the circular economy to try and benefit from it and not only save money but perhaps sell what we have, not for scrap but for its rare earths or the minerals within a particular piece of equipment?" We could actually make some more money. There are great opportunities here if we have a different mindset, and the different mindset is to see everything as an opportunity rather than see it as either waste or a threat.

Q49 **Derek Twigg:** In terms of climate change, how do you think it will affect how our armed forces operate? For example, they could be in the High North or the Arctic. What thought has the MoD given to our armed forces operating in a changing climate?

Lt Gen. Nugee: Earlier this year there was a big exercise, which the Royal Marines and Royal Navy took part in, and in fact one of our aircraft carriers, up in the north. It is the first major exercise that we have done in the north. I think the Navy is very alive, as is NATO and the Secretary General, to the changing environment in the Arctic. The scientists predict that the Arctic will be open water in the summer in about 15 to 20 years' time.

That has two implications. One is that we do not want that to be seen as a Russian internal sea, which they have declared their intent to make it. I do not think it has been passed in Parliament, but certainly there was a law in the Russian Duma which, if not passed, said that it was a Russian internal sea. We, as people who believe in free trade, free movement of goods and so on, would not I believe accept that, so we need to be able to operate in the High North. The Americans have stood up a command that has specific responsibility for the High North and the Arctic, and NATO is taking it much more seriously than it used to 10 or 15 years ago, when it was not expected that it would melt.

I would argue that between the frozen sea in the winter and the open water in the summer there is a period of time when the ice is not thick enough that it needs an ice-breaker, but is too thick for the very thin hulls of our warships. That has been recognised by the Russians, the Chinese and the Canadians, as far as I am aware, who are hardening the hulls of some of their ships so that they can operate in what the Canadians call disruptive ice. I think we should be doing the same; not of course the whole fleet—we do not need that—but enough of our fleet so that if we were required by our Government to have a presence during that period of the year, we would have the capability to do so and to not cede that to the Russians, for example, who will have that capability.

The High North will change the dynamics. There are downsides to open seas in the High North—for example, I think I am right in saying that 23%[2] of the world's trade goes through the Suez canal. It is certainly a

[2] Approximately 12% of global trade passes through the Suez Canal, representing 30% of all global container traffic and over USD $1 trillion worth of goods per annum.

significant proportion, as we saw when that ship banked in the canal. That will be reduced very significantly if we can use the north-west passage or the northern passage. That will have an impact on Egypt, because a lot of its revenue comes from the Suez canal. These are not simple issues, but I think that the MoD is alive to the High North and how it is changing, and to the fact that we will have to operate in that area in due course.

Q50 **Derek Twigg:** And the south?

Lt Gen. Nugee: The Antarctic is interesting. The Antarctic is melting—I went down there last Christmas to do some science research, and I think the figure is that 79% of the glaciers are melting[3] down in the Antarctic, and melting at a speed that is being accelerated by hot water coming in under the glaciers and undermining the ice shelfs.

Antarctica is, if you like, governed by the 1960s treaty[4], which does not allow any military capability on the Antarctic. I do not know, but that is a treaty that is only 60 years old, and for the time before that, and potentially time after, that treaty might not hold. There is some evidence that some countries are showing some interest in the raw minerals in Antarctica. I really hope that that treaty holds, because it has been fantastic for the past 60 years-odd to try and make sure that Antarctica is as pristine as it can be.

Q51 **Derek Twigg:** I have one more quick question, but by all means tell me if you feel not able to answer it. One of the weaknesses in supply lines for fuel and energy is supply dumps, which we have seen the Ukrainians make quite a thing about. Do you think that as we become greener, including in how we power our vehicles, Armed Forces and energy, that sort of fragility will get better for the Armed Forces? Or will it be about the same, needing these huge fuel dumps that we have seen for many generations? How would you see that given the change in climate, the greening of the Armed Forces and so on?

Lt Gen. Nugee: It has to be put into context. It is said that, on average a soldier in the second world war used approximately one litre of fuel a day, and a soldier today uses 20 litres of fuel a day. That is obviously an average of all the soldiers divided by the number of litres.

What's the "so what?" of that? Our soldiers of the future will be more power hungry; there's no doubt about that. We are electrifying the environment around the soldier so that the soldier has better situational awareness. The whole idea is to try to make the soldier more connected with his or her colleagues. So it is an environment where the demand will probably rise, notwithstanding the efficiency that you can get out of going green, to a greater or lesser extent, whether it is an additive to fuel that increases efficiency by 6% to 8%—that is a little bit, but it reduces the maintenance burden by 30%, because it effectively increases the quality and cleanliness of the fuel, if that makes sense.

[3] 87% of the glaciers are retreating.

[4] The treaty was signed in 1959.

We can do what we can to try to reduce the requirement for fuel—I talked earlier about the 70% efficiency for a generator—but the demand will go up, I would suggest. I do not know whether that will require more fuel dumps or fewer, but what I do know is that it will be a different dynamic.

Q52 **Derek Twigg:** In terms of logistics, it is a challenge then, one way or another, isn't it?

Lt Gen. Nugee: Yes.

Derek Twigg: Just for the record, it is useful to say in respect of the earlier conversation that it was Colonel Rupert Thorneloe who was the most senior officer who was killed.

Lt Gen. Nugee: Thank you very much indeed.

Chair: Rupert Thorneloe and I were at Sandhurst together and it was very sad news when I heard of his death—he was killed in July 2009. He was a good friend. We have platoon reunions from Sandhurst regularly and his father stepped in to fill the spot in the picture that we took when we were on the steps of New College. It was wonderful to see his father, but it was very sad to learn of his death. I think he was the most senior—

Lt Gen. Nugee: He was the most senior British officer killed in Afghanistan.

Q53 **Chair:** Can I just turn, if I may, to the consequence of our having to lean on our armed forces to deal with the problems of climate change? Do you foresee a greater burden being placed on all three services when we see increased extreme weather in the UK and when other services and so forth are then hit by the consequences of climate change, not just in the UK but in other areas of the world where we have interests?

Lt Gen. Nugee: I think the answer to that is yes. RAND did a study for me to look at the implications, and they came back saying that humanitarian assistance and disaster relief will be an increasing part of the requirement for the MoD's services, if I can put it like that—so, for the Army, Navy and Air Force. We have seen that in this country with the dam in Derby, where the RAF did a fantastic job of trying to shore up the dam by dropping shoring from a Chinook.

In Canada, 500 troops were deployed just recently to deal with the effects of climate change. Of course, in Pakistan the troops are very heavily involved in trying to solve some of the issues of the flooding there. One other example is that the Navy now routinely puts a ship to cope with the effects of the hurricane season out in our overseas territories in the Caribbean. When I joined Defence in the early '80s, that wasn't a routine deployment; it was an occasional deployment. Now it is absolutely routine. So yes, we are already seeing more and more of our troops being used for humanitarian assistance and disaster relief. I can only see that increasing.

I want to comment on our allies as well, because if the forces of our allies—let's take Pakistan, which is an ally, and Bangladesh is another very

good example—are completely preoccupied with coping with the outcome of climate change, whether it is flooding or drought or whatever it is, they are not doing the job that, as allies, we would want them to do, which is to protect their nation, because they cannot be in two places at once, in a sense.

By extension, it makes us more vulnerable, I would argue, if our allies around the world—as well as our own overseas territories, which will distract some of our troops into that environment—are not able to do the job that they are designed to do as military folk protecting their national security. That then weakens the web of allies and alliances that we have as a nation. So in my view we should be concerned with what our allies are having to do to cope with climate change just as much as with what we are doing to cope with the outcome of climate change.

Q54 **Chair:** So if you are a wily adversary, you would perhaps be taking advantage of the fact that nations across the world will be increasingly distracted by the challenges of climate change, which will inevitably place greater burdens on the Armed Forces. This happening at a time when the world is getting more dangerous, not less. We have entered a worrying era of insecurity, with a deteriorating global situation. We are facing so many complex and dynamic threats, but none of them is as significant as climate change. The impact on global security will be huge, with increased competition over limited resources that will test Governments around the world, placing ever greater burdens on defence forces. It is absolutely critical that we start to upgrade our defence posture today in readiness for the security challenges that are coming over the horizon. Would that be fair?

Lt Gen. Nugee: Yes, and I think there is one other side, which is that all Governments have a finite amount of resources. If they are spending more and more and more on the consequences of climate change because they haven't been able to adapt, they will inevitably and potentially—I obviously wouldn't advocate this—spend less on defence. In a world of finite resources and prioritisation, if you are looking after your people because they are subject to climate change, something has to give. I would suggest that countries around the world are experiencing that far more than we are.

The other point is that this is already happening in the sense that 80% of the refining capability of the materials needed for renewable energy, whether rare earths or other materials, is in China. As a personal view, I would say that it is a security risk that we are utterly reliant on materials that are refined in China in order to be able to create our own renewable energy in this country.

Q55 **Chair:** That is a very powerful statement, which we need to factor in. I just wonder whether the review of the integrated review will also consider these factors. The review itself has come back to the drawing board because of Ukraine, but everything we have been discussing here suggests that there is another dimension to the integrated review that needs to be factored in. Are you able to do so with Professor John Bew? Are you able

to provide some of the work that you are doing to say, "We cannot be cutting 10,000 troops. We cannot be cutting back on the number of ships. We cannot be cutting back on the number of planes"?

Lt Gen. Nugee: I think that would be beyond remit, if I may, Sir, but the Ministry of Defence is alive to the national security implications and threats that emanate.

I will just give one other example, which is the effect of the Ukrainian war—I know you have just been in Ukraine. I wonder if it is a coincidence that the majority of the rare minerals that are required for renewable energy in Ukraine happen to be in the Donbas. I wonder if that is a part of the calculations that are made. If Russia can dominate them, which is where Europe was hoping to get its minerals from for its own renewable energy transition, it denies them to Europe. I don't know—of course I don't know whether that was within the thinking. It might just be an unfortunate coincidence, but it is there all the same.

Chair: If there are no further questions from my colleagues, then can I say that this has been a really illuminating session? We are very grateful indeed as we take a closer look at the relationship between our Armed Forces and climate change. It is great to see you back here. Thank you for your contribution today.