Baillie Gifford

Nuclear innovation

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Two nuclear-related developments pose an opportunity for investors and broader society. In his Disruption Week webinar, investment manager Luke Ward discusses advanced small modular reactors and how SHINE Technologies is forging a profitable path to fusion power.

Your capital is at risk. Past performance is not a guide to future returns.

Malcolm Borthwick (MB): In 1950, the AC Gilbert Company launched the Atomic Energy Lab. It's since been dubbed the most dangerous toy in history. The kit included radioactive substances and a Geiger counter for kids to pay hide-and-seek with them. Despite the obvious perils, it reflected the excitement in the so-called Nuclear Age, an age that promised cheap and abundant energy. The reality, however, has been more complex. A series of accidents has undermined confidence and rising regulations have led to spiralling costs.

In today's Disruption Week, we'll be talking about whether or not atomic energy is getting a second chance. That's due to the growth in smaller modular reactors and mimicking a process that powers the sun and the stars.

Hello, and welcome to Disruption Week, I'm Malcom Borthwick, managing editor at Baillie Gifford. And I'm joined by Luke Ward, our investment expert in nuclear energy. Luke, great to have you with us.

Luke Ward (LW): Hello, nice to be here.

MB: And just a reminder, the webinar will be about 40 minutes. Luke and I will chat for the first 25 minutes and then we'll open it up to questions from you, the audience. So we'd love to hear from you. If you do have questions, please use the 'Ask a question' button which is on the right of your screen. And we hope our conversation will prompt plenty of questions from you.

Luke, I wanted to start, because we'll be talking both about nuclear fission and nuclear fusion, could you just tell us the difference between the two?

LW: Sure, so nuclear fission is taking heavy atoms and splitting them apart into smaller atoms. Nuclear fusion is the opposite, it's taking small atoms and squishing them together into larger ones. Both of those processes release heat which can be used to extract energy.

MB: And in the introduction we talked about the Nuclear Age. Could you convey the excitement and interest in the 50s

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around this Nuclear Age?

LW: Sure, so when we talk about the Nuclear Age we're talking about fission, that first process of taking heavier atoms and splitting them apart into smaller ones. This was discovered at the beginning of the early 20th century, perfected during the 30s and the 40s, and then used as a basis for energy generation from sort of the 50s onwards.

And the enthusiasm there was that up to that point we'd just been burning trees and dead dinosaurs in order to power our civilisation, a chemical reaction which has got quite limits to it and also creates quite a lot of environmental externalities. Whereas here we had this atomic energy source, a very science fiction way of powering the future, but incredibly power dense, incredibly energy dense. So you only needed a small footprint, like a small battery, a small powerplant, in order to provide an enormous amount of power compared to the powerplants we'd had in the past.

So the hope was that this could be a better and a cheaper way of generating electricity. It was coming on the back of a lot of enthusiasm about the world of the future, technology, where is civilisation going to be in the year 2000, etc. And here was the big unlock for us, this incredibly energy dense energy source that was going to sort of bulldoze through a lot of the energy challenges we were going to have over the next couple of decades.

MB: So Luke talked about the world of the future there. I'm going to ask you about the world of the present in our poll, and how much of the world's electricity comes from nuclear. So the choices you have are 2 per cent, 5 per cent, 10 per cent or 20 per cent. So if you could pick one of those and we'll come back with the results a little bit later on.

But let's move through from the Nuclear Age to, I guess, the 60s, 70s, 80s, what happened in that in-between period with nuclear?

LW: Yes, so up until about the 80s, which I'm sure we'll get on to talk about, there was a huge programme of building out nuclear power sources. The number of reactors went up from zero to around about 400 reactors, I think, by the end of the 80s, which were installed around the world. So this really big rollout of nuclear power, across countries, across continents. Predominantly in the western hemisphere, I'd suggest, rather than in the eastern hemisphere. But this came to power quite a significant chunk of society and people started extrapolating about, oh, we're going to have nuclear-powered spaceships and nuclear-powered cars, etc. There was a lot of enthusiasm about it.

MB: And it did start to wane, didn't it, in terms of that enthusiasm. What happened?

LW: Yes, there was a particularly jarring event, or several, actually. First the Three Mile Island disaster, where you had one of the reactors which overheated and released a little bit of radiation into the atmosphere. But then a much more significant event which was the Chernobyl incident in Ukraine in 1986, where you had a full reactor meltdown.

So these really big safety and environmental concerns around nuclear power. We thought we'd been able to harness the atom and capture it in almost a god-like way, but here was the folly in that. Mostly due to human error and design error rather than the inherent technology. It was the way in which some of these reactors had been designed and the human operators not having the correct safety procedures in place, which then, when some of these reactors were run in an experimental way, caused these horrendous accidents.

MB: It's quite unusual for us to go from one massive extreme to another. That's created quite a lot of fear of nuclear energy. Do you think that fear is well-founded or slightly irrational? What's your view on that?

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LW: Yes, I guess the case in point at the time was that people had been overenthusiastic and sort of underplayed the risks around radioactivity and meltdown issues. But a lot of that technology, and without wanting to sweep it under the carpet, a lot of that technology is from the 60s and 70s, whereas many of the reactors that are being designed today are intrinsically so much safer than those of the 60s and 70s. Which, whether people admit it or not, had this sort of dual purpose of subsidises a nuclear weapons programme. And so the operating parameters and designs which you might have employed in the 50s and the 60s are very different to the ones which we're employing today.

So, reactors have got a tonne more regulation, a tonne more safety infrastructure around them today. The designs are inherently a lot safer, passively cooled rather than actively cooled, etc. So it's not to say it's absolutely perfect and there's no risks associated with it at all, but there are many more improvements which have been made since then.

MB: And we'll stay with nuclear fission, but it's almost like, I guess, fission has been given a second chance here. Tell me a little bit more about that and some of the innovations that we're seeing here.

LW: Sure, so I think after the incidents in the 80s, no one wanted to build a nuclear powerplant in their backyard, so the enthusiasm for it amongst the public as well as amongst the financial backers just completely evaporated. So, if you still needed to rollout a couple of nuclear powerplants to replace the ones which are going offline, or to provide energy for society, operators had to build far fewer reactors in very specialised locations. So rather than having this volume approach to nuclear, they had to have this bespoke large-cap approach to it, almost.

So we ended up building a handful of very large but very specialised reactors. That destroyed the economies of scale which we were getting within nuclear power, and so the costs got way ahead of themselves. And so rather than being this better and cheaper resource, it turned out to be a much more expensive one. So we didn't build out very many nuclear powerplants.

What's happening today, and I guess over the last sort of 10 to 15 years that some of these reactors have been developed, is taking the approach of: rather than building these really large reactors why don't we build much smaller modular reactors. So we can build them in a factory to a standardised design, ship them to a site, install as many as we need for the given purpose and try and get those economies of scale. That Wright's Law in terms of, if we can increase the volume production, can we access the cost efficiencies which make this palatable and cost-effective to install.

MB: Because some of these large reactors, the costs are, and I guess we've seen this in the UK, they've gone from 20, 30, 40 billion. But the modular ones are, what's the comparative cost, presumably they're a lot less?

LW: Sure, so the hope is that at scale these will be much cheaper, so the watt per dollar cost of them will be much cheaper. The initial prototypes are always quite expensive. So I think the initial prototypes which people have built are equivalent to the larger nuclear reactors we're building today. But that's very much of a first-of-a-kind design. The hope is that when you get to the tenth carbon copy of this design, or the hundredth, that cost can come way down. Because a lot of the overhead, the initial design overheads, are just depreciated on that initial reactor, and so you don't have to carry that cost across the rest of them.

MB: And what type of companies are we seeing specialise in these modular smaller-scale reactors?

LW: So, there's a handful of start-up companies, smaller companies, which are doing this from fresh, who have begun to

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undertake this work. And then there's a handful of larger companies as well. So I think lots of the traditional nuclear manufacturers, I mean you've Rolls Royce, you've got EDF for example, GE Hitachi, the larger companies which are pursuing these, they're seeing this potential disruption threat to the larger reactors. And people like Bill Gates or Sam Altman from OpenAI are funding their own smaller nuclear companies like TerraPower and Oklo Energy.

MB: You've talked about some of the advantages of the modular reactors. Typically, where are they being deployed?

LW: So none of them have been installed yet, but I think the exciting thing for smaller reactors is that you can retrofit existing power stations with them. So we're trying to get rid of a lot of coal power stations at the moment, particularly in America and in the UK and Europe, etc. And those communities need something to take that place that was often the anchor of the local economy. And so if you can reinstall a small nuclear reactor to take the place of the coal furnace, you can use all the existing electrical infrastructure, you can use a similar workforce, and you can rejuvenate these sites. And you can also get them for really cheap because they've been depreciated over the past 40 years. And so it's quite a savvy, cost-effective way to install smaller nuclear power.

Some of the reactors are going to be installed on traditional nuclear sites as well, so rather than needing to go through all the same level of permitting that the large reactors have done, they can just be built as a module on the side of these traditional reactors and benefit again from a lot of the capital that's already been spent on the infrastructure.

MB: And are they less wasteful in terms of the decomposition of the waste, the modular ones, compared to the larger ones?

LW: Yes, so they need less fuel than the larger ones. It depends what kind of fuel as well, and what kind of methods they use for cooling. So one of the really exciting things about some of the smaller designs is that they can be completely passive, so you don't have to have any human interaction with a reactor for 20, 40 years. They're designed to be installed at the site and then removed and disposed of elsewhere, so people have really thought about the whole lifecycle of these. So rather than having to transport the individual fuel, you might just transport the individual reactor. It's small enough so that we can dispose of that and nothing ever leaves the containment field within that.

MB: I'm going to go back to our poll before we move on to nuclear fusion, just to see what everyone's view was on that. And just a reminder of the poll it was, 'How much of the world's electricity do you think comes from nuclear?'. And our audience has said, so 2 per cent was 16 per cent, 5 per cent was 36 per cent, so that's the largest amount, 10 per cent 33 per cent to round it up, and 20 per cent was 14 per cent. So, most people went for 5 per cent, were they right?

LW: It's more like 10 per cent.

MB: 10 per cent, yes. Well quite a few people went for 10 per cent, so that was pretty good.

LW: There's some big bars on that. France, for example, is almost 70 per cent, the UK is about 15 per cent.

MB: So let's move to nuclear fusion, which is, I guess if we think of fission [as] what we're working on at the moment [and] fusion being the future. The big advantage for fusion- We were talking earlier about the decomposition of nuclear waste, firstly give me an idea about how long that waste takes to decompose. And then secondly, tell me what the advantage is of fusion.

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LW: So within traditional fission, so all the stuff that's come in the past, some of that highly radioactive waste has to be stored for millennia. People are designing repositories to survive the next Ice Age, so it's a very long-term problem that people don't like to discuss but it's quite a large liability as well. It's manageable within that, but it would be great if we didn't have to worry about that environmental liability and that huge capital cost that comes with it.

So fusion now, which is this taking lighter elements and joining them together, doesn't use a highly radioactive fuel source, it doesn't use uranium or plutonium. It just uses isotopes of hydrogen, things which are available in seawater and lithium elsewhere. And so you don't have any of the radioactive waste associated with fusion. The disposal is just the initial fusion reactor [which] will be slightly radioactive but no more so than some hospital radiation departments, for example. So they're much more likely to be regulated as a low-radioactivity source, which we're much more used to dealing with, rather than having to have this high radioactivity overhead that traditional nuclear infrastructure has. That's one of the big attractions of fusion, if we can get it to work, is that we don't have this huge radioactivity problem.

MB: Yes, if we can get it to work. That's the really tricky thing, it's very hard, isn't it? Tell me quite how difficult it is, fusion?

LW: Yes, it's very hard. We've been trying for the past 70 years to harness a fusion reaction. Still waiting for that to happen. We had some progress, I think, in the end of last year. The laser ignition facility at Lawrence Livermore in California was able to create the fusion conditions of a net energy gain, so extract more heat out of a tiny fuel part than they got put into it. But that used a titanic laser array and in no way is designed for capturing energy. Someone described it to me as compressing a fusion plasma is sort of like trying to get jelly and hold it together with elastic bands whilst you're heating it up to 100 million degrees Celsius, it's an incredible engineering problem. We're making incremental progress towards it, but it's been very, very hard to do, to date.

MB: Because it's about trying to get more energy out than you put in. Tell me a little bit more about that process.

LW: Yes, so the sun does it because it's just so gravitationally dense that it almost- it basically implodes itself and forces atoms of hydrogen together. So it uses its gravity to do that. But we don't have the luxury of doing that on earth so we have to find other ways to do it. So, high-powered magnets using lasers, using pistons, etc, high energy discharges. Fusion happens in lightning bolts, for example, it's these kind of intense power levels which we need to do that. The computation which is involved with managing something like that on the microscale is just enormous.

Usually when we've been doing this in reactors, we've been able to get it for a flicker of a couple of seconds, maybe a minute, but nowhere near the power levels at which we would get more energy out of it than all the effort we had to put in to create those conditions.

MB: So yesterday with Kyle we were talking about artificial intelligence, is there any deployment for artificial intelligence here, potentially?

LW: Yes, so this has really helped the fusion field, in particular, over the last couple of years, in terms of: rather than having to run experiment after experiment to define the nature of the problem and all the variables within it, can we apply computer codes, machine learning, AI, however we want to define it, to better search that solution space for us? So that's had a really beneficial impact on narrowing down the kinds of experiments we need to run in order to learn more about fusion. But it's not a cure for it, it can't design a fusion reactor for us, we still have to put in some of the hard yards in order to find what the solution is going to be.

MB: So let's talk about some of the companies involved in nuclear fusion. There are around about 40 which have raised capital and they've raised round about 6bn. A lot of them are in the US, there are four companies in particular that have raised round about 200mn or more. One of which is SHINE, which you like. Why?

LW: So most fusion companies are tackling a really hard engineering problem to try and ultimately sell a low-margin commodity, to sell energy. If you need to then fund R&D around that process for the next 10, 20, however many years, without a cash flow to support that, it's not going to be a sustainable financial model for you to follow unless you can keep on getting injections of cash, which some of these companies have done very successfully. And it's great that people are willing to fund that.

But the challenge for us, and for our particular clients, is that where do we sit on the risk-reward there? What is a more attractive place for our clients' capital to sit? So the reason why I quite like SHINE is that SHINE are using fusion technology but they're using it develop high-margin products in the interim, rather than go straight to energy generation. So they're using the principles of fusion in order to do neutron imaging so they can image carbon composite materials, which are really critical components in aerospace at the moment, or image turbine blades.

They're also then using this technology to create medical isotopes, small bits of material which we can attach onto antibodies which seek out cancer. We can use it to both diagnose and to treat cancer, it's like a local version of internal radiotherapy. So again, really high-margin but really large market potential in oncology for curing cancer there. So they can use the cash flows from this to continue subsidising their fusion technology, which helps them sell more of those products, but also helps unlock the harder challenges they need to progress onto that energy generation stage.

MB: And some of these treatments could be a lot less invasive in terms of cancer than some of what we've got currently, couldn't they be?

LW: Sure, in some cases they've been curative for stage four cancer in some people, phenomenal treatments, but it's just been very hard to manufacture these molecules at scale and discover them at scale. And so this is what the fusion technology has allowed to happen- is there a cost-effective, scalable way to manufacture those.

MB: And it's interesting, SHINE have got these four phases. [This is] currently in the first phase. Is that profitable yet or is it close to profitability?

LW: Yes, so again going back to that sustainable financial model, we need to build a business which is sustainable as well as a product which is sustainable. Profitable in that imaging case, hopefully going to be profitable in the isotopes case this year as well.

MB: Yes, so I guess the challenge for you as an investor, you want to identify finding a company that's solving a problem which we've clearly got here, but also one that's going to be able to execute and make money on the journey. I mean SHINE sounds pretty rare in that regard.

LW: Yes, I mean all companies are working towards this, it's a question of how much capital do they need to spend to get there and how long is it going to take them. I think disruption inevitably has to be better and cheaper than what's come before it. I think in a lot of cases, technologies like this are almost always better, it's can they be cheaper. And within that cheaper aspect of it, scale is usually the big challenge of it, so can we make it cheaper at scale?

It's fine that these things are maybe affordable to do in a lab but if you want to make an impact on civilisation or have a large growth market these innovations really need to be scalable. And I think that's the problem which rightly people are trying to solve but different approaches have got different chances of making that happen.

MB: Yes, probably the largest project is an international which one, which is in France, isn't it? What advantage do SHINE have over a lot of the public projects, being not just a company but a private company? Does that give them an edge?

LW: I think so. A lot of innovation in this space tends to be top-down rather than bottom-up. A reason why there isn't a lot of nuclear innovation is, if you come up with a new way to do an enrichment technology or a new way to produce fuel, etc., if you're lucky you get a visitor from the international atomic agency, if you're unlucky you geta stealth bomber visiting you instead.

And so there really isn't an environment to support bottom-up innovation, or traditionally hasn't been. A lot of the funding has been more for top-down. And when you have top-down, prescriptive innovation it tends to be less capital-efficient than bottom-up innovation, in my opinion. It's definitely got a place, but in terms of making businesses and scalable businesses it's not necessarily targeted at that sort of profitability aspect of it, it's much more targeted around a research objective.

So, one of the reasons why we like SHINE and other companies within this space is I think they're bringing this entrepreneurial energy, this start-up mindset to a field that's lacked that for the last 70 years. And so, they're approaching these problems from first principles, rather than taking the regulatory book, what does the regulation say we can and can't do, and then designing something around that basis. They're going, 'What are the actual engineering dynamics, the physics dynamics, the monetary dynamics that we need to think about for having an impact on the world and how can we harness those to make something that then conforms to regulation?'.

MB: And that's really interesting, I mean this is Disruption Week, but that's almost a kind of classic disruption model. It's almost much easier to disrupt from the outside than the inside when you have inherent biases and proxy and it's very hard to change.

LW: I think so, I mean I don't want to do a disservice to the phenomenal research effort that goes on. A lot of these companies can only exist because of the efforts of, often, government funded research there, so it 100 per cent has a place and it's really important to continue. I think that does well in the science and R&D phase, but less well at the commercialisation stage, which I think is where these companies are really targeting.

MB: Yes, so a combination of both. There does seem to be a correlation in terms of the business models of SHINE and possibly SpaceX, which I also know that you're interested in, in terms of, I guess, a couple of things. I guess with space and nuclear there was a lot of progress, then a gap, then progress. But also between the two companies in terms of being able to make money along the way for the ultimate huge goal, fusion energy with SHINE and space exploration, possibly, with SpaceX. Do you see these similarities between the two companies?

LW: Yes, I think when we're approaching our researcher looking for ideas, finding areas which have been chronically underserved by innovation is usually quite a good place to start. The caveat of that is it usually means that innovation takes quite a long time to crop up as well, so I think you have to have that long-term perspective to look in these kinds of areas.

But space and nuclear have got many similarities in terms of, there was lots of enthusiasm in the 50s and 60s, that all went away in the 70s and 80s, you had very little progress, costs, regulation, capital going out of the market, etc. But also a concentration of the companies within that. So you have a handful of aerospace companies which have dominated space. You have a handful of energy companies which have dominated nuclear. And eventually that just creates such an inefficiency that it's worth the while of some of these entrepreneurs to try and have a go at challenging that status quo.

And so we see a very similar thing happening in nuclear today that happened in space around about 20 years ago with Blue Origin, SpaceX, etc. I like it because we're starting to see the seeds of this, it's not that all of these companies are directly relevant to our clients today, but the impact which they could have and the relevance which they could have in five, ten years from now I think could be really significant. And again, we've seen that in other industries that we've invested in.

MB: And there is a crossover between nuclear and space in terms of propulsion for rockets and various other things. Tell me more about that.

LW: Yes, I think if the space race had carried on a lot of the experimentations which were going to happen in the 70s and 80s were around nuclear-powered rockets. So how do we get to Mars even quicker, how do we fund a large space station or a lunar base, etc. We needed a nuclear power source, this really energy dense, small form factor energy source that we could take anywhere in the solar system. That was going to be the real supercharger on space. But again, as we've discussed, when that economic model isn't there it's really hard to fund that continual innovation or make the case for it.

MB: And what do you learn from talking to both the founder and CEO of SHINE? What do you learn from him about industry trends and other investment opportunities in fusion?

LW: I think it's really good to be able to touch base with, well not just Greg, but lots of entrepreneurs which we talk to and invest alongside, around getting their take on the wider industry dynamics. The press is very good at giving a top-down perspective on things, academia is good in terms of if you have questions around the science, etc. There's not really much of a resource in terms of looking at the economic realities of a lot of these industries or the business challenges within them. They don't tend to get a lot of airtime and you really need to talk to the people within them, I think, to get an appreciation of the competitive dynamics, or what are the challenges to scale, or why pursue this growth opportunity first rather than that one, etc.

It's not immediately clear from the outside, so we really want to make an effort to get to know as many of these companies as possible. One, because we think we might be able to invest in them one day. But two, because, I think, we learn a lot more by investing in talking to these people, to help us inform investment decisions in the future.

MB: We talked briefly about the idea of recycling nuclear waste and that's something that SHINE is working towards. Could there be an element where fusion helps fission here?

LW: Yes, so the next problem which SHINE want to go after is that really big nuclear waste liability we talked about earlier. All these fission plants which have been running for decades and creating this nuclear waste which we have to store, it would be great if we had a much better and cheaper way of solving that problem, but to date we haven't had one. Again, [due to] the lack of innovation, lack of incentive, lack of capital to support that.

With SHINE, the fusion technology they use to create isotopes is the same technology if applied at a higher power level which can be used to treat nuclear waste, so turn this nuclear waste into something that is almost like alchemy turning gold into lead or vice versa, rather. You can take this uranium and split it into other atoms like rare earth elements, which might be useful for recycling into batteries and advanced technologies. And really siphon off that really intense, bad version of the waste and treat that into a form which can nullify a lot of the longer-term risks associated with it. So you wouldn't have to do this intense millennia-long storage for it, you could handle it in a much shorter period of time.

MB: And I guess the fourth stage of SHINE is almost like the holy grail, really, of creating this cheap and abundant source of energy. How far away, do you think, are we from that? And with your engineering background, do you see a gear change in [the] progress that we're making?

LW: Yes, I mean this industry is fraught with people who've made predictions about oh, it's just going to be here in 10, 20 years and you come back in 50 years and it isn't. So it's a bit of a cautious one in terms of making predictions. I think what has changed is that you've now got a much better toolset to use, you've got the capital which is interested in disruption and you've got the individuals who are really passionate about making a difference here. So, I think we've got more of the ingredients to accelerate that change and to make that happen.

Lots of private companies predicting 2030s, if you talk to academics sort of 2040s, 2050s, if you talk to government it's still a bit of a research project. I think probably somewhere in the average of there, I'd like to hope, is where the truth lies within it. But there's a lot more progress that needs to be made. To date we've been focussed on the scientific challenge of just making the science work. Beyond that we've got an engineering challenge, can we make these reactors cost-effective? And then we have a commercial challenge, can the power from fusion be cheaper from the power from fission, or from geothermal, or solar, etc.?

So it's a really hard thing to do, but the prize for doing it is substantial. Energy is going to be the true limit on growth for our civilisation. There's this incredible correlation between GDP growth and energy consumption. If we want to be able to make things more affordable, energy is at the foundation of all these aspects of our civilisation. So, if we can find a way to make that better and cheaper that's going to unlock so many more growth opportunities for us.

MB: We're going to come to your questions in a minute, so if you have any questions please do ask them and use the 'Ask a question' button which is on the right of your screen.

I wanted to ask you just maybe one or two more questions firstly. You mentioned the engineering challenge there, and what I'm interested in is your background is also in engineering. In terms of your research, what guides you in terms of looking for companies? And is it kind of tied into that engineering expertise or where do you tend to go, or what are the limits?

LW: I guess it's quite a broad brush when we're looking for innovation more generally. So that maybe has a bit more of a top-down flavour to it, which kind of areas of the economy do we think are going to be ripe for disruption or we see disruption happening. But I think very quickly, that's just a starting point. In order to figure out which companies are going to have an edge within that is really important. Which companies are going to be more scalable? Which management teams are pursuing strategies which we think align with those goals over the long-term, over the short-term, etc?

I think very quickly, particularly within these kind of disciplines, the engineering path which these companies are pursuing really informs the nature of the edge which they're going to have and the nature of how scalable the business models will be. So, I quite like finding companies where that is the second question we get to ask: ‘Who’s got a better engineering solution?’ ‘Who’s following first principles rather than a more generic, prescriptive design approach?’. And I think that can really unlock the exceptional companies within these industries, rather than the more generic and the also-rans within the company.

I think, again, SpaceX and Tesla, Musk has done a very good job of instilling an engineering-first culture within these businesses. Boeing used to have one back in the early days when they revolutionised the aerospace industry. I think finding those kind of businesses and cultures which have that at its core, there can be inefficiencies with that. Sometimes engineers can be blind to the commercial realities of what they’re pursuing. But if you can harness the engineering in a way that aligns with that, you can have really powerful businesses.

MB: And what typically gives you the confidence that these companies are going to execute?

LW: I think there, again, everything within investing is probabilistic, but we’re looking for what can tip the odds in the favour of our clients’ capital. And so, particularly designs there, take fusion for example. Are companies optimising for a scientific goal, can we just make heat out of a reaction and maybe win a Nobel Prize, which would be great? Are we optimising for an engineering goal, can we actually make electricity out of that process? Or are we optimising for an economic goal, that’s all well and good but can we make money from doing this? And often those are three different kinds of businesses, or three different people running each of those businesses.

Finding those which can overlap the three of those pursuits successfully is really important because for investors it only has value if you get to that end-point and you can create a business around it, which is generating cash flows. And that’s how society’s going to benefit, it’s not going to be adopted unless we can get to that point.

So finding companies which embrace all three aspects of their product there, I think, is really important. I think too often we see companies which maybe embrace just the one, and that’s great for a couple of years and it pushes the field forward but I don’t think it’s going to be a high-returning, enduring business to invest in.

MB: Yes. And now it’s time, let’s go to your questions.

There’s plenty of questions that have come in, thanks very much for submitting them. The first one, Luke: what would make you move your family to live next door to a nuclear power station? And what would make you not?

LW: So we do live quite close to one, actually. There’s one just further down the coast from our office here. So I think a lot of people are unaware of just how close an awful lot of people do live to these sites.

The question is sort of tail risk, is there a very, very small probability of a severe event happening? I’m confident that with the regulation and the designs which we have that’s extremely unlikely to happen. I think with everything in life you can never say… Nothing is impossible, right? But the safety record for these reactors is really, really strong. A lot of the designs which were used in Chernobyl, for example, inherently unsafe reactor design.

The Fukushima disaster, there was a magnitude nine earthquake and a 15-metre tsunami which washed over the entire area, caused an awful lot of damage. These are, sort of, tail risks events which we’re not subject to in most of the western hemisphere, within the reactor designs or where they’re sited.

MB: So the sectors and companies you follow, where is the most exciting innovation and disruption?

LW: I think for us at the moment, we're probably seeing it most in space and with SpaceX in particular, around the Starlink network. So global broadband availability, global connectivity, I think is a really powerful tool to have. But it's interesting to see the different industries we have, how they line up in terms of are they relevant over the next two years, five years, ten years. So, if we look a few more years out I see quantum computing as a really impactful technology which is starting again to overlap with that engineering and commercial reality, rather than just being a science project. Nuclear fusion is maybe a little bit further out than that, but again in 10, 20 years' time I think that could be really relevant for us.

MB: You spoke about some western companies. What about the nuclear-related investment opportunities in places like China, which have huge energy needs of their own?

LW: Yes, so China and other emerging markets around that area are actually the ones which are really building out nuclear power at the moment. I think South Korea, India, etc, as well. So they're really in growth mode around this, they recognise the need to decarbonise. They rely an awful lot on coal powerplants, how are we going to make a cleaner energy source in a centralised way? Nuclear power really suits for that. I think it probably helps there that the regulatory environment, it's probably a bit easier to get nuclear powerplants built than it is in the west, perhaps.

But the investment opportunities there are a bit more limited. Again a lot of these companies tend to be quasi-government entities that are really government owned. And so investing either in those companies directly or specifically within the nuclear aspect of what they're doing is quite difficult for individual investors.

MB: And will nuclear fusion always be a backup to renewables? Or is it safe and relatively clean, could it supplement or supersede them?

LW: I think renewables, if we call that geothermal, solar, wind, wave, etc, are always going to have a place. It's not to say that nuclear in general, or fusion specifically, is going to end up replacing all of them. I think, as we're seeing from some of the grid dynamics, you need a real mix of energy sources in order to cater for the consumption needs which we have. If we were to come back in 100 years, say, I think that will probably be quite different. I think we'll likely end up [with] something more like solar and fusion and the rest wouldn't have those cost efficiencies at scale which will allow them to keep being affordable in that state.

MB: That's a serious long-term view there. And you mentioned a couple of start-ups during our conversation, Rolls Royce is one. What do you make of their efforts?

LW: Rolls Royce are really pioneering, I guess, the UK approach to small modular reactors. They were designing reactors for quite a long term, for the last couple of decades, for submarines, for naval architecture, etc. They've got a really good gas turbine business which would be the heat equipment that would plug into it. So, they've got all the ingredients which makes sense for them to pursue this approach. They're building a consortium, I think, around these. The question at the moment is, which approach is the government going to fund given there's a competition going on. Which design is going to win out, where are they going to be located, etc.

Rolls Royce are using a traditional technology and making it smaller. I think quite a few of the start-ups are taking newer technologies out of the lab and [trying to] make them larger. So there's maybe a difference in flavours of which approach might be superior there, but again it depends which site we're looking at. So does it make sense to put a Rolls Royce

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SMR near an existing Rolls Royce nuclear plant or nuclear infrastructure? Possibly yes. Does it make more sense for a start-up to go to a coal plant? Maybe yes.

MB: Okay, time for one more question. Amongst your colleagues across Baillie Gifford, how much interest are you seeing in nuclear fission or fusion technology, for that matter?

LW: To be honest not an awful lot at the moment, I think that's because the investment relevance of it is still emerging at present. So it's really important for us if we're thinking about what are we going to invest in for our clients over the next ten years. We need to get to know the technologies, the areas, the people who are going to be driving innovation over that time period. So, in the next couple of years, who do I want to be talking to, where do we want to be investing our clients' capital. Setting the stage for that now is really important to have access and to have insights in order to be able to do that well.

So, I think over the next five or so years it's going to be really relevant to us. But it underpins so many other industries as well, we've been talking about AI and the building out of computation. The real barrier to scale within AI is going to be how do we have the energy to support this level of computation. It's no surprise that Sam Altman, who has pioneered OpenAI, is funding a nuclear fusion company and looking at nuclear fission as well. Energy is really the funnel through which a lot of these other technologies are going to have to pass through. Without it we're not going to have these large growth opportunities, so I think it's going to be really relevant for so many more investment opportunities we have.

MB: And if there's one thing you'd like to leave the audience with, a closing point or comment in no more than a minute, what would it be, Luke?

LW: Yes, I think when we look at nuclear we're always looking at it through the rear-view mirror. We did the same with space, we did the same with quantum, we do a lot with these kind of high engineering, high potential, but difficult-to-scale technologies. Whereas I think the forward-looking view is much more optimistic about it, the technologies which have the improvements which have been made over the decades in this. The insight which is being brought to bear by these entrepreneurs is really powerful, and I think the future is going to be radically different from the past in this industry. And that's really exciting for us as long-term investors.

MB: Such a fascinating topic, Luke. Thanks so much for joining us. And I hope you, the audience, have enjoyed the conversation as much as Luke and I have. If you'd like to find out more about Disruption Week and the other topics that we've been discussing, such as the new wave of disruption, how physical and digital assets are merging together, check out **bailliegifford.com/disruptionweek** where you can find recordings of our webinars and also articles summarising what we've been chatting about. And if you've got any questions, or you'd like to follow up on any points, please get in touch with your client contact or email us at **disruptionweek@bailliegifford.com**.

And tomorrow, we're going to be talking about the energy transition and the idea of injecting huge amounts of sulphur into the atmosphere to reflect sunlight in order to cool the earth. This sounds crazy, but could it be practical? Well, join us tomorrow.

In the meantime, thanks for investing your time in Disruption Week.

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