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A portrait of Carol Tansley, a woman with long, straight, light-colored hair, wearing black-rimmed glasses, a white collared shirt, and a dark grey blazer. She is smiling and looking directly at the camera.

CAROL TANSLEY

CAROL TANSLEY ON WHY A NEW WAY OF WORKING MUST EMERGE TO
DELIVER SMALLER, MODULAR NUCLEAR SOLUTIONS

Nuclear is plotting a new path towards smaller, modular, more efficient reactors that can decarbonise both electricity and industry. But to deliver on its promise, X-energy's Vice President – UK New Build Projects **Carol Tansley** believes a new way of working must emerge

The world of nuclear is changing. Focus is moving from gigawatts to megawatts, from large one-of-a-kind reactors to small or even micro reactors that can be built on factory lines and rolled out en masse. It is, according to Carol Tansley, an exciting time but one that requires the industry to rapidly re-focus to ensure it has the capability to grasp the opportunity that is there for the taking.

Tansley has spent much of her career working on titanic government-driven projects, initially outside the nuclear industry but more recently with the Nawah Energy Company in the Middle East, where she led the delivery programme for the reactors at Barakah. In doing so, she helped it to become one of the rare major gigawatt nuclear projects that have been delivered on budget and, believe it or not, actually ahead of schedule.

Since then, she has moved to the opposite end of the scale, joining US-based nuclear start-up X-energy to spearhead its UK operations. The firm is one of many pioneering operations that are entering the sector, looking to capitalise on the commercial opportunities offered by the hunger for smaller, more nimble reactors to achieve net zero targets. But to do so, Tansley states, the industry needs to itself become more entrepreneurial.

"It's great having all this innovation in the technology, but we need innovation in the project delivery and the commercial models as well," she asserts. "If you follow traditional approaches, you will just get traditional outcomes. So we need 'institutional entrepreneurs' to look at the institutionalised way of doing things – like the forms of contracts that get used over and over again – and find more entrepreneurial ways of changing those frameworks.

"I think we now recognise our responsibility and take it very seriously. We have to deliver these projects on time and on budget and with the modular reactors, you are able to build them faster, replicate and get the benefits of learning by doing. The efficiencies that you drive out then in terms of delivery and cost can be significant, but making that successful will be about the way they are constructed, commissioned and brought online."

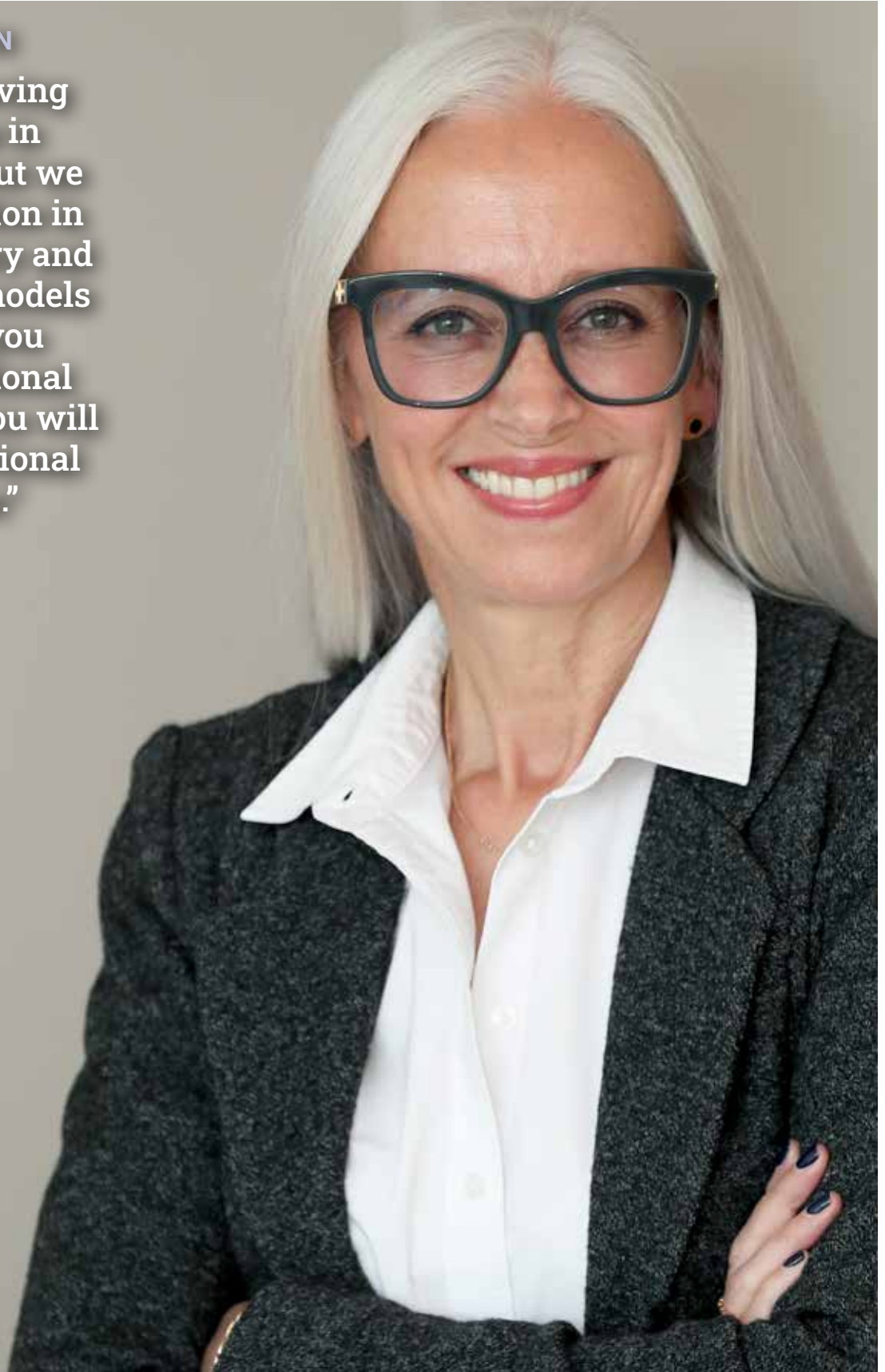
TOTAL IMMERSION

Tansley is not a traditional nuclear lifer. She went to a business school to study International Business and Modern



IN PERSON

“It’s great having innovation in technology, but we need innovation in project delivery and commercial models as well. If you follow traditional approaches, you will just get traditional outcomes.”





Languages and lived in Nantes for a year to perfect her French. Back in the UK, she rapidly made a name for herself within the halls of Government working for consultancy firms in support of major transformation programmes. That time in France, however, was key to her success, as it taught her how to learn quickly.

“There were only three people from the UK amongst 150 French people and all the business lectures were taught in French,” she recalls. “At the same time as learning the language, I was trying to absorb the business concepts so I ended up having to develop quite a lot of mental shortcuts to be able to learn. That really does accelerate your understanding.

“I think that total immersion in any subject is the way to really develop your capability and your knowledge very quickly. Learning in a different culture was also a real privilege as

it really broadens your perspective. It teaches you to be more tolerant and to understand how important it is to recognise there are always multiple perspectives and viewpoints and they may often differ from your own.”

Business school was all about solving real world business challenges and Tansley accrued a wide range of experience working on projects with an optician chain, a yacht builder and a breakfast cereal manufacturer. The diversity continued in central government, with projects on the introduction of Incapacity Benefit and Job Seekers Allowance in the 1990s and on HMRC’s implementation of the update to the National Insurance Recording System.

It was then when the Middle East came calling. Tansley moved to the region to work on a major transformation programme for the Ministry of Interior with Abu Dhabi police, prisons, borders and civil defence.

“

Total immersion in any subject is the way to really develop your capability and your knowledge very quickly.”



She then transferred to Saudi Arabia to work with the Minister of Labour and the Director General of one of the departments focused on getting young people into training and development to support the indigenous labour market. Her roles typically involved taking the overall strategy then developing and delivering the implementation plan.

Nuclear had not even been on Tansley's radar until an unmissable opportunity came out of the blue. "It was both deliberate and serendipitous," she says. "I had reached a point in the Middle East where even though I was still enjoying the work, I didn't feel like I was being challenged professionally and I didn't feel like I was learning anything new. I was at a point in my career when I thought 'I've only got one big thing left now and I really need to figure out what that is and what I really want to do.'

"So, I ended up taking a career break

for three months to give myself a bit of space to think about it. I had already been thinking about transferring into the energy sector because that is where I felt the major challenges would come from, but I realised that nobody was going to take me in as a consultant into a new industry sector without me having that deep sector experience. So, the only way to do it would be to join a company as a line professional.

"Then I was sitting at my kitchen table one day and got an email that just said 'we've seen your professional profile on LinkedIn, would you send us your CV?' It was from Emirates Nuclear Energy Corporation! I sent it and they called me within the hour and within three months I had got a start date for my new position. The planets were aligned and the reason I was of interest to them was the major programme experience."

BUILDING BARAKAH

It was straight back to the 'total immersion' approach for Tansley as she quickly absorbed as much information on the nuclear sector's technology and its unique culture as she could. Her eyes were quickly opened, as she recalls: "I was surprised how many executives had never done anything other than nuclear and I think we really could benefit from looking more broadly cross-sector at what others can bring to the industry.

"The principles across all industry are broadly the same: you need to see the big picture, understand exactly the intent and scope of the project, then work out how to deliver it, who will deliver it and build the schedule to support that. The biggest challenges I had when I arrived were the terminology, the highly regulated environment, the complexity of what had to happen and the multicultural dimension."





You are never going to be able to walk in somewhere, see an answer and fix things. It is always multi-dimensional.”

As those in the industry know all too well, nuclear has a dogged reputation for going over budget and over schedule. Coming from a different background, Tansley had seen how other operations are run, so when she arrived in the sector and had combined her new knowledge with that from the past, was she immediately thinking ‘I’m going to make this change, I am going to make nuclear deliver like it is supposed to’?

“No, not at all,” she says. “I have learned over the years that projects are staffed by clever people and the complexity and environment is always extremely challenging. You are never going to be able to walk in somewhere, see an answer and fix things. It is always multi-dimensional, so I went in with the approach of trying to understand and learn as much as I could, then figure out ways of trying to apply what I knew to help solve the problems.”

When Tansley arrived at Barakah, in 2014, Units 1 and 2 of the four-unit project were already under construction. She helped to establish the project management office, dealing with specific individual projects that fed into the overarching programme, such

as the new simulator, then stepped into the Strategic Program Director role to establish Nawah as the independent entity that would hold the operating licence.

Four years after she joined, she co-led a ‘schedule reset’, in which the entire four-unit programme was assessed, a detailed delivery schedule was created and an overarching governance and programme body, the ‘Operational Readiness Control Centre’ was created to take on full responsibility for leading the delivery of that schedule to time and budget. Tansley was asked to lead that body, and spent the next four years working towards the opening of Unit 1.

“Our team sat across the whole programme to make sure we had a fully-integrated schedule for everything we needed to do to get Units 1-4 online,” she explains. “Obviously, the major focus to start with was on Unit 1 and we were lucky enough to go live two days early, on 17 February, 2020. We are all very proud of that. It was amazing. When everybody had been working so hard together, the day we got our operating licence was a very emotional day.”

FLAGSHIP SUCCESS

Barakah has been acknowledged by many as a flagship example of how new nuclear should be, and can be delivered. Tansley was fortunate enough to see the secrets of success first-hand, and believes that everyone can benefit from the lessons learned. In fact, she reveals, the team in Barakah and those on Hinkley Point C have had delegations travel in both directions in an effort to feed that success into the UK’s nuclear new builds.

So, what exactly was it that made Barakah achieve what is so often seen as impossible in the nuclear industry? Tansley explains: “The country’s vision was very determined and they put the right leadership in place and the right team to make it happen. A set of underlying principles was established at the outset and we just kept coming back to them. They included: ‘no compromise to safety or quality’ and a ‘one team’ approach. ‘One team. One goal.’ That was the culture, and the leadership mantra was ‘we all get there together.’

“One of the biggest challenges at the beginning was trying to set up the company at the same time as delivering the programme. Even the regulator was being set up in parallel, so we had evolving regulatory requirements. It helped that everybody was incentivised to work together across



the organisation and we had daily status meetings, so we knew where we were against the schedule every single day.

“We only monitored a couple of key metrics, but by doing it every day if problems emerged, we knew about them straight away and everybody got in to fix them together. Things weren’t allowed to drift. The way we built the schedule, we knew where our critical path was and what the next 19 paths were and we always monitored them. If anything came up on those paths, we would divert resources to contain it so we avoided the slippage.

“We did have big challenges – some technical, some procedural, some environmental, some around fire protection – but because of the way the leadership established the culture, we had this early warning system so we could see problems emerging and tackle them straight away. It was a huge privilege to be part of that programme and the thing I learned most was the importance of having leaders with the skillset to deliver and the ability to inspire.

“For me, I think that comes down to creating a culture of psychological safety at work. You need people on the project to be able to come in and want to give their best, but also to know that they can raise issues and challenge things if they do not think they are right. I really do think that having the right kind of environment is so important, not just to nuclear but to any major programme.”

NEW OPPORTUNITIES

After the emotional success at Barakah, it was another point of reflection for Tansley. Having come into nuclear from working in different industries she had “got quite tired, quite quickly” of having her understanding questioned or challenged due to her lack of nuclear background. She built a thick skin and a determined mentality to get where she was, but she always felt her major programme experience deserved a more formal credit. She discovered a Masters programme at Oxford University whilst at Barakah and once Unit 1 was delivered she decided it was now the time to finally go for it. “I always wanted to have something to stamp on my forehead to say ‘you’re a professional in this sphere,’” she smiles. “To do it, I needed to be able to make the time commitment and I wanted to make sure I had enough experience to contribute and get the most out of it.

“I started it in September 2020, right in the middle of the pandemic, and I was still working at the same time. It was eight one-

week modules across two years and I got so much out of it. In particular, I learned to look at how I had done things through different lenses, from an organisational perspective or a systems thinking perspective, and to really look at the complementarity of deterministic and probabilistic planning and forecasting.”

Tansley’s main research area was different commercial models and their impact on project outcomes, including a new approach called Integrated Project Delivery. This caused her to get back in touch with a former Barakah colleague, George Vanderheyden, who had since gone on to be a senior executive at X-energy. The two had a long conversation and a year or so later, she had moved back home to steer the company’s path in the UK.

“I had been on the Barakah project for eight years and by the time we had almost got Unit 3 online, the scale of my role was starting to diminish,” she explains. “I wanted to find my next challenge and I wanted to be where the next technology was coming from – SMRs, AMRs. I was starting to look around at different technologies and I actually contacted George to interview him for my dissertation.

“I was looking into the potential of introducing Integrated Project Delivery into the nuclear sector. It had never been used on a nuclear reactor project, so I was exploring the opportunities and barriers. It turned out he had come across this methodology and was looking into using it for X-energy, so I researched the company and the more I looked at it, the more excited I got. Then he asked me if I was interested in leading the UK operations.”

The company is developing a new Advanced Modular Reactor (AMR), the Xe-100, which can output 80MW of electricity or 200MW of high temperature steam, with the potential to combine individual units in blocks of four for larger capacity. They use a proprietary fuel called TRISO-X, which the company also manufactures, and the plan is to site them near to industrial plants – from chemicals companies to synthetic fuel producers – to support the wider goals of decarbonisation.

Generation IV High Temperature Gas-Cooled Reactors (HGTR) like this have sometimes been seen as a longer-term solution, with light water SMRs more in the spotlight for the nearer-term future. Indeed, some of the SMR designs currently being developed are hoped to be up and running before the end of this decade. However, if

QUICK FIRE QUESTIONS

Q: Who is your professional mentor?

A: I don’t have a single person I turn to for advice and coaching. I have multiple people I call on, both inside and outside the industry. I find the diverse perspectives helpful.

Q: What has your nuclear career highlight been to date?

A: Receiving our operating licence for Unit 1 at Barakah. It was the culmination of years of hard work by a lot of people. The CEO brought a copy to my office the day we received it. It is now framed and on my wall.

Q: If there’s one thing you wish more people knew about nuclear, what would that be?

A: That successful nuclear new build delivery in the future requires not only innovative technology, but innovative project delivery and commercial models.

Q: What advice would you give to young people seeking a career in this field?

A: I would wholeheartedly encourage them to do it. I have learned more in the last eight years of my career than at any time before. It can be very challenging, but it is hugely rewarding. And we are changing the world!





X-energy's progress continues the way it is going, the dawn of the AMR might not actually be that far behind.

"There has been a narrative that says the SMRs based on 'existing technology' are for today and new technologies are for tomorrow – but we are not the next generation, we are the now generation," says Tansley. "We are on the same timeline as the SMRs. We have \$1.2bn in grant funding from the Department of Energy in the US to deploy a four-pack of our reactors and develop our commercial fuel fabrication facility, which is already under construction.

"Our goal in the UK is to be a fast follower of what is happening in the US. If we deploy four in the US, we will deploy the fifth in the UK so we can leverage a lot of the learnings. From a technology point of view, that eliminates a lot of those 'first-of-a-kind' variables that are often a concern. By the time we deploy in the UK, we will have de-risked a lot and that is why we think we will be ready by the early 2030s."

INNOVATION

In the UK, the eventual formation of Great British Nuclear (GBN), if and when that happens, promises to lay down the strategy for future development. In a recent interview with *Nuclear Future*, Simon Bowen, revealed that AMRs are in the mix and that the Government is open to the idea of including them alongside one or two more gigawatt plants and a host of SMRs as part of the drive to achieve 24GW of nuclear by 2050.

That is positive news for Tansley, who is already working with her team to explore siting options for X-energy's first UK AMR in Teesside. "We are looking at the places best suited to flexible application," she explains. "The Teesside area emitted 3.1 megatons of carbon dioxide last year, so as soon as we can help to decarbonise that, the better. That region also has advanced gas cooled reactor heritage, a very experienced supply chain and a skilled workforce."

Interestingly, X-energy might have been set up in the US but the technology of both



fuel and reactor are not actually new and exotic at all, they are based on long-standing UK heritage. The reactor has origins in Dragon, a design that was built by UK Atomic Energy Agency (UKAEA) at Winfrith and operated from 1965 to 1976, while TRISO fuel was first patented in the UK in 1957 and has been used in prototype and full-scale demonstrators since.

The pebble-shaped TRISO-X fuel created by X-energy contains microscopic kernels of uranium coated in indestructible layers of carbon and ceramic. The fuel retains the waste and fission products and X-energy says it cannot melt under any of the temperature scenarios that their reactor will see. It effectively forms the containment vessel, eliminating the need for the huge steel and concrete structures and expensive safety systems associated with conventional reactors.

The simpler design has around one tenth of the systems traditionally involved in a nuclear reactor, making it simpler, quicker and cheaper to build. The turbine generator

can be air or water cooled, giving a lot more flexibility in geographic siting, and, Tansley says, the way the fuel works, the low reactor power density and the self-regulating core, all mean that if cooling stops, the reactor shuts itself down, a form of passive safety system.

The nuclear island – the reactor and steam generator – has been specifically designed to be independent of end use, which will be either clean electricity generation or high temperature heat and steam to support industrial processes. That means it is very flexible. It can provide base load, but its operations can be adapted to load follow very efficiently, helping to balance out the variable generation from renewables on the grid.

“There is space for everybody,” says Tansley. “The government ultimately will take a view on the mix of technologies that have different things to offer. With AMRs, the high temperature steam and the ability to decarbonise the industrial sector help to provide a solution that nobody else in the market can at the moment. We do not have an answer to that available to us today.

“I think, in 15 years’ time, the UK will have at least two new big gigawatt reactors operational, maybe three if another is deployed, then from our point of view we will certainly have our first four-pack operational, ideally in Hartlepool, and our own UK fuel fabrication facility too, as we are very supportive of the ‘UK fuel for UK reactors’ mantra. Then, alongside us, there could be other SMRs and AMRs providing clean energy and industrial heat.

“I have heard Simon Bowen speak on this topic and I absolutely support his vision that we need a programmatic approach for nuclear in the UK. I think that goes for technology companies, the supply chain and to attract talent into the sector in the first place. I hope that when GBN is set up, they will be looking programmatically about the wider power and industrial decarbonisation challenge and which technologies we need to support that.

“There is a lot of opportunity for a lot of different players to get involved in this process and it would be super helpful if that was one part of the focus for GBN, with another being mapping those technologies to different sites. I also hope that they will be looking at expanding the siting policy to make sure we are all clear what that map looks like in the longer term.”

COMMERCIAL REALITIES

Ultimately, the ability for the UK to deliver new

“

By the time we deploy in the UK, we will have de-risked a lot and that is why we think we will be ready by the early 2030s.”

nuclear successfully will come down to the operational and organisational procedures that are put in place. This is something that Tansley knows extremely well, from her time at Barakah, from her experiences in consulting across a range of industries and through her most recent studies, where she looked in detail at why certain nuclear projects have failed to meet timeline and budget objectives.

“Item number one on the list is unrealistic planning and forecasting,” she says. “That can be through ‘optimism bias’ – so thinking you can do things faster than you can because somehow you think you will do it better than other people have managed in the past – or through ‘strategic misrepresentation’ – where sometimes people will deliberately underestimate things in order to get their project off the ground.

“When I was doing my research, every one of the executives I spoke to about a project that went over time and budget told me something unexpected had happened. That shows that on projects of this scale and complexity, there will always be things you cannot foresee at the start. You need to plan for emergent change and build schedules with margin, so when any problems arise you have the time to fix them and get that margin back again.

“Item number two would be insufficient time spent in upfront planning – front end



CAROL TANSLEY C.V.

Tansley comes from a background in consulting and only entered the nuclear sector part way into her career. Having managed major projects and taken roles in the Middle East during her way up the career ladder, she is now in back in the UK in a prominent position within new nuclear. These are her key senior career roles:

2009 – 2014	PwC – Senior Director
2014 – 2016	Emirates Nuclear Energy Corporation - Head of Program Management
2016 – 2018	Nawah Energy Company – Director of Strategic Programs
2018 – 2022	Nawah Energy Company – Operational Readiness Control Centre Director
2022-Present	Vice President – X-energy UK New Build Projects

loading or front-end engineering design. The biggest mistake that is often made is people not completing the design prior to the start of execution. It is simple logic. The more uncertainty you take with you into execution, the more likely you are to go over time and budget and the more severe those overruns are likely to be.

“The third is not considering well enough the commercial and project delivery model. You hear a lot of talk about the need for collaboration – and I am a 100 per cent aligned with that – but there is no point saying that and then putting an adversarial contractual model in place. You need to think creatively about commercial models that incentivise behaviours around project outcomes, rather than individual outcomes that can lead to opportunism.”

This inclusivity is the basis of the Integrated Project Delivery concept that Tansley explored in her dissertation research and, as mentioned previously, it was this way of working that helped Barakah deliver as promised. The Operational Readiness Control Centre, sitting across the top of the entire construction process, was able to keep an eagle eye on every part of the project. So, could that approach work for other projects?

“Well, when a project is so complex with so many interdependencies, you absolutely need it,” she says. “That’s exactly the kind of approach they had at the 2012 Olympics in London and for Heathrow Terminal 5. They had a fully integrated schedule and a fully integrated team, working together to make sure that it all pulled together.”

“My research showed that failure on nuclear megaprojects is strongly associated with first-of-a-kind variables – not those per se, but the fact that the project delivery and commercial models selected are not resilient in first-of-a-kind environments. The

Integrated Project Delivery methodology – based on relational contracting and interparty collaboration – has been used on hundreds of major infrastructure projects, primarily in the US and Canada, with really good results; performance levels of 95%-plus successful projects.”

Clearly, whatever the methodology, to deliver the levels of future nuclear required in the UK and globally, there will need to be a rapid development of skills and knowledge. To set the ball rolling, Tansley says, there needs to be a firm government commitment to new projects that will provide realism and a sense of security, reassuring the industry that this is not a repeat of the nuclear renaissance in the early 2000s, which never got off the ground.

That means a commitment to education, support for mid-career transitioners and also fast decisions on the regulatory changes that will be required to shift from a small number of large reactors to a large number of smaller reactors. In terms of X-energy alone, the ambition is to supply around 3.2GW of energy, which equates to around 40 of its reactors – a minimum of 10 ‘four-packs’ – that will all be seeking homes around the country.

“In terms of regulatory challenges, we hope to be able to leverage the experience we have in the US and Canada,” says Tansley. “I completely recognise it is a totally different regulatory regime, and we need to deal with our regulator independently of that, but I think we can still learn the lessons from over there to make sure the quality of our submissions can help the UK regulators as much as we can.”

“In some of our early sites, the reactors are likely to be configured in a pack of four and in certain cases we would probably want to put more than one pack of four on the site. Later on, however, we may want something smaller

With AMRs, the ability to decarbonise the industrial sector help to provide a solution that nobody else in the market can at the moment.”

for other locations, but that is the strategic direction that the industry is going – to try and find sites that are not just the traditional big remote locations. That’s something that everyone needs to adapt to.

“With the supply chain, we need a pipeline of opportunities before parties will be willing to invest. We have already started that engagement, but it is something that as a sector we all need to work on together. This is where the collaboration needs to come in to make sure we are working with bodies such as the NAMRC and their Fit4Nuclear group to help build out that supply chain that has dwindled over the last two decades due to gaps between orders for new plants.”

In the past, nuclear has often overpromised to get projects off the ground. In the face of other options, such as wind and solar, large-scale reactors have always involved such large budgets and timelines that governments wanting quick wins have sided with other technologies. So, if government and commercial entrepreneurs can finally sit side by side on nuclear, will that be the end of promises that fail to deliver? Tansley believes it must.

“Overpromising leads to failure and unfortunately it leads to industry failure, not just project failure, because all you are doing is adding to the data set of failed projects,” she asserts. “It reinforces the view that nuclear projects are not commercially successful. So, as an industry, I believe we need to be looking at trying to support and grow the technologies that are more scalable and more simplified.



“The simpler they are, the more you get away from this complexity, expense and duration. I think the new companies coming into the industry have looked at it and said ‘what is the solution to delivering projects more successfully, while making sure power plants do what we need in the modern world’ and they have seen the benefits of these more modular approaches. And those who lead the way, I think can make a real difference.”

