NUCLEAR AMRC news
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Look to the future

Technology and skills for a new generation of low-carbon power

CATAPULT
High Value Manufacturing

Seeing is believing: Nuclear AMRC CEO Andrew Storer and Chris Skidmore MP discuss the centre's welding research.

Science minister sees the **value of collaboration**

Science minister Chris Skidmore visited the Nuclear AMRC to see how the centre works with partners to support new low-carbon power plant.

Skidmore was re-appointed as Minister of State for Universities, Science, Research and Innovation following December's general election. He visited the Nuclear AMRC and its sister centre, the University of Sheffield AMRC, in January as part of a tour of key organisations in the north of England.

The minister met with Nuclear AMRC CEO Andrew Storer, University of Sheffield Vice-Chancellor Koen Lamberts and other senior staff to discuss how academia, industry and government can help rebalance the UK economy by working together to improve productivity, processes and skills.

"This excellent work is supercharging manufacturing in the north of England, demonstrating the importance of industry, academics and government collaborating to boost prosperity," Skidmore said. "Driving innovation in all parts of the UK is vital. We're determined to harness brilliant research like this, to grow the economy and secure our status as a global science superpower."

During the minister's visit to the Nuclear AMRC workshop, Storer highlighted how the centre's engineers are supporting the development of new forms of low-carbon electricity generation, including government-funded programmes such as the UK SMR consortium led by Rolls-Royce and UKAEA's Spherical Tokamak for Energy Production.

The Nuclear AMRC is working on a host of manufacturing technologies which can significantly improve productivity for key reactor components, such as electron beam welding which can join thick-walled pressure vessel sections in a fraction of the time of conventional methods.

Speaking at the University of Durham a week after his visit, Skidmore highlighted the work of the High Value Manufacturing Catapult as a flagship example of business-led innovation tackling the future challenges of nuclear, aerospace and construction. The Nuclear AMRC and AMRC are both part of this seven-centre network.

"The unrivalled manufacturing expertise and R&D capabilities in this Catapult are helping industry to respond to the opportunities and challenges of new technology – bringing the so-called fourth industrial revolution to life," he said. "This Catapult has been the very model of success – supporting over 4,500 projects in the last year alone, with their work benefiting companies of all shapes and sizes, including almost 2,500 small and medium-sized firms."

Insphere joins Nuclear AMRC

Innovative metrology company Insphere has joined the Nuclear AMRC as a member, to support ongoing development of its on-machine measurement and verification technology.

The Bristol-based company has worked with the Nuclear AMRC since early 2018 to develop its Baseline system.

Baseline can provide full verification of a large machine tool in less than one hour, facilitating regular checks and providing confidence in performance prior to cutting metal. The Nuclear AMRC hosted the product's launch in March 2019, after Insphere's engineers worked with the centre's metrology and machining team to test and develop Baseline on its largest machine tool platform.

"We're delighted to become a member of the Nuclear AMRC," says Ben Adeline, Insphere chief executive. "This confirms our ongoing commitment to work with the centre to develop innovative methods of improving machine tool performance through the use of metrology data. This will form a critical part of our company strategy to develop state-of-the-art products to serve the advanced manufacturing community."

Becoming a tier two member of the Nuclear AMRC will allow Insphere to work closely with the centre's researchers to develop its technology, tap into the centre's other advanced machining and metrology research, and build links with leading manufacturers in the supply chain for nuclear and other quality-critical industries.

Insphere engineers are now installing the Baseline system on the Nuclear AMRC's Soraluce FX12000 horizontal boring machine, and will provide ongoing technical support as part of the company's membership. Capable of working on pieces of up to 12 metres length and five metres diameter, the Soraluce is the largest machining platform available for collaborative R&D in the UK.

"I'm delighted to welcome Insphere as a full member of the Nuclear AMRC," says Dave Stoddart, head of simulation and verification at the Nuclear AMRC. "Their Baseline system will enhance the capability of our Soraluce machine by enabling rapid validation of its current performance, ensuring we can tackle highly challenging machining operations with confidence.

Machine trials: Ben Adeline of Insphere tests the Baseline system on the Nuclear AMRC's Soraluce FX12000.

"Insphere have a proven track record of delivering highly innovative complex solutions, and we look forward to working with them and helping the UK's nuclear supply chain access their expertise."

The Baseline system uses laser tracking technology, provided by Nuclear AMRC member Hexagon Manufacturing Intelligence, to rapidly create an accurate three-dimensional picture of the machining platform. Insphere's software runs the instrument to gather the data, then applies a set of algorithms to determine variations in any of the 21 forms of geometric error encountered in three-axis machine tools, plus any variation in the rotary axis.

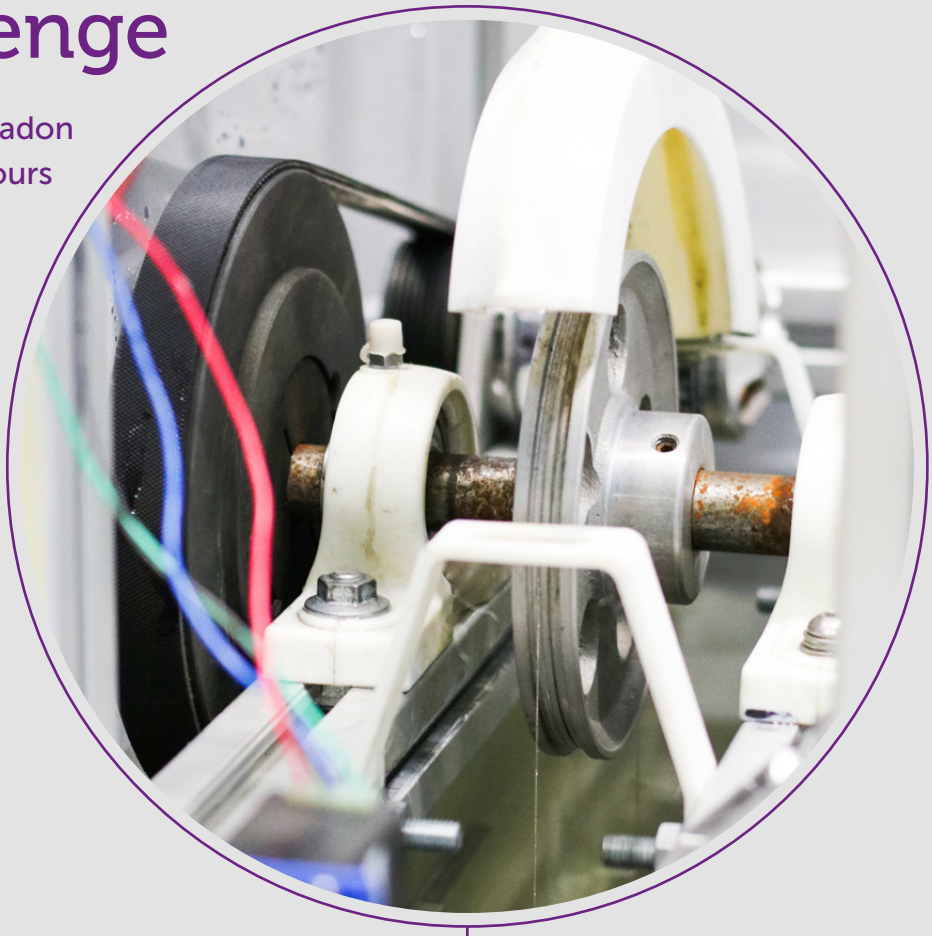
The process takes between 30 and 60 minutes for a rapid "health check" verification of all axes and squareness. A full verification, including tests of the machine's dynamic response, can take from 45 minutes to two hours depending on the size and complexity of the machining platform. The system can also run a full ISO230 compliant test.

By allowing rapid identification of any problems, Baseline can improve productivity by enabling preventative maintenance before anything goes awry, minimising the risks of unexpected downtime, and reducing scrap. The data can also help integrate large machine tools into modern digital manufacturing systems.

inspherelt d.com

Eadon tackles **decommissioning cutting challenge**

Engineering design specialists at Eadon Consulting called on their neighbours at the Nuclear AMRC to help them tackle a challenge for Sellafield.



Diamond wire: Eadon's prototype cutting machine.

Based at the AMP Technology Centre on Rotherham's Advanced Manufacturing Park, Eadon was awarded funding by Sellafield Ltd through its LINC programme. LINC is designed to help smaller companies bring innovative solutions to the challenges of safely decommissioning the Sellafield site.

Eadon's challenge lies in one of Sellafield's fuel storage ponds, where remotely-operated underwater vehicles (ROVs) are set to begin clean-up operations. There is currently a metal obstruction blocking access between two areas which are in a particularly challenging environment. Sellafield required a method of remotely cutting and removing the obstruction, and Eadon was selected after proposing an initial concept for a small-scale, long-reach diamond wire cutter.

Diamond wire cutting is typically used on large-scale demolition projects, but is also used on a smaller scale to cut gems using methods which could be adapted for the Sellafield application.

To demonstrate the feasibility of the diamond wire technique and optimise its cutting parameters, the team had to build and develop a test rig. With limited space in Eadon's own facilities, the Nuclear AMRC provided space in its own workshop, allowing the Eadon team to carry out initial testing and process proving over several weeks.

"In the spirit of collaboration and supporting SMEs, the Nuclear AMRC were able to quickly respond to the request for help and enable the testing to get underway," says Eadon director James Hill. "This has built on our existing relationship, and we are now looking at other opportunities to collaborate on R&D projects."

The Eadon team are now developing the final design of the machine to be deployed into the Sellafield pond. By using their experience from the test rig development, as well as drawing on other ongoing research and development projects, the Eadon team were able to use off-the-shelf components and technologies to accelerate development time while reducing cost and improving reliability.

Hill says the firm's experience of developing innovative solutions for the nuclear sector meant that it was able to quickly develop a concept that takes the best of established techniques and adapts them for use within the nuclear sector.

"This project builds on our current R&D program within the nuclear sector, which now covers topics as diverse as waste containers, access and deployment systems as well as size reduction capabilities," he says.

Eadon has previously worked with Sellafield through the Game Changers programme, which aims to identify innovative solutions to specific decommissioning challenges. Eadon's Reach project developed a mobile camera system controlled by a mobile app, to access and inspect difficult-to-reach areas of a post-operational nuclear plant.

eadonconsulting.co.uk

> "In the spirit of collaboration and supporting SMEs, the Nuclear AMRC were able to quickly respond to the request for help and enable the testing to get underway." **James Hill,** Eadon Consulting

K-TIG to tackle challenges of waste box welding

Welding technology specialist K-TIG has joined the Nuclear AMRC to develop new high-performance fabrication techniques for waste containers and other nuclear applications.

Based in Australia, K-TIG has developed a patented keyhole welding technology which can produce welds 10–100 times quicker than conventional tungsten gas arc welding, joining metals up to 16mm thick in a single pass.

The technology is already in operation with some of the world's largest fabrication businesses, and is also accessible to small and medium-sized manufacturers.

The Nuclear AMRC has worked with K-TIG to assess and develop the technology for nuclear industry applications since 2015, with recent research focusing on waste containers made of duplex stainless steel.

By joining the centre as a tier two member, K-TIG will deepen its partnership with the Nuclear AMRC to help manufacturers in the UK decommissioning supply chain improve productivity and reduce costs for waste container fabrication.

"The Nuclear AMRC's approach to developing highly advanced manufacturing techniques and processes for the benefit of the nuclear sector through industry partnerships with leading technology providers is unrivalled globally," says Neil Le Quesne, president for market development at K-TIG.

"K-TIG intends to build on the last several years of collaboration with the Nuclear AMRC, to become a long-term partner and to collaborate extensively in solving the productivity challenges associated with fabricating the tens of thousands of nuclear storage containers required by the UK nuclear decommissioning programme over the coming years. The Nuclear AMRC's focus on exceptional weld quality, negligible distortion, high corrosion resistance and stable material properties under the most demanding conditions is the identical focus as K-TIG's, and we look forward to co-developing solutions that will deliver highly tangible commercial outcomes."

By working collaboratively with the Nuclear AMRC, the K-TIG team aim to overcome some of the key manufacturing challenges associated with fabricating nuclear storage containers, assist in building capacity in the UK supply chain, and enable UK fabricators to compete globally in meeting the requirements of the many countries now dealing with nuclear decommissioning.

Sealing the deal: the Nuclear AMRC's Sean Eley with K-TIG's Neil Le Quesne.

As part of its membership, K-TIG will upgrade the Nuclear AMRC's current equipment, and provide additional training to the centre's weld engineers and technicians.

"We're delighted to welcome K-TIG as a member of the Nuclear AMRC, which builds on several years of association and collaboration between our two organisations," says commercial director Sean Eley. "We see K-TIG as a key industry partner to help us address the productivity, cost and quality challenges of nuclear waste container fabrication."

Nuclear AMRC engineers are tackling a wide variety of challenges in decommissioning, including around the cost-effective manufacture of waste containers. By developing and applying new technologies and processes to current and future designs of container, the cost of decommissioning can be significantly reduced in the UK and worldwide.

"K-TIG's keyhole welding technology has already proven to be extremely effective in nuclear waste container fabrication, and we look forward to working collaboratively to further expand these capabilities through a long and mutually beneficial industry partnership," Eley says.

As well as waste container fabrication, the technology can improve productivity for other nuclear industry applications made from corrosion-resistant materials, including pressure vessels, heat exchangers, tubes and pipework down to 75mm diameter.

The K-TIG technique uses a high current arc to open a keyhole through the join between two surfaces, fusing the parent material with little or no wire added. It can produce a stable keyhole at much lower energy densities than other keyhole welding technologies, and uses as little as five per cent of the energy and gas used by conventional welding.

k-tig.com

Nuclear AMRC Midlands boosting skills and innovation

A year after its launch, Nuclear AMRC Midlands is delivering innovative projects in sensors, control systems and digital manufacturing, and helping the region's young people develop skills for the future workforce.

Transferring knowledge: programme director Dr Emma Kelly.

Nuclear AMRC Midlands is based in the iHub facility at Infinity Park, a 100 acre site to the south of Derby city centre managed by the D2N2 local enterprise partnership (LEP) and Derby City Council.

The centre is playing a key role in developing the park, and is in ongoing discussions about building a full-scale bespoke facility which could play the same anchoring role as the original University of Sheffield AMRC played for the Advanced Manufacturing Park in Rotherham.

"We're working with Derby City Council and D2N2 to bring the High Value Manufacturing Catapult to Infinity Park," explains Dr Emma Kelly, Nuclear AMRC programme director for the centre's Derby and Birkenhead facilities. "It'll be led by the Nuclear AMRC, but it'll be an inlet into the whole Catapult network for regional businesses."

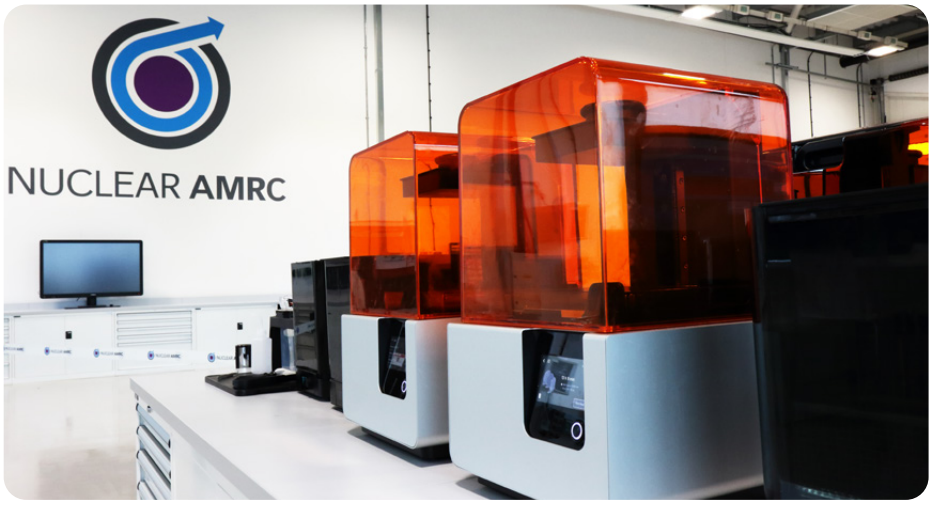
The Nuclear AMRC now has 15 engineers and support staff working at iHub, developing capabilities in new technology areas and working with companies across Derbyshire and Nottinghamshire to support key local sectors for advanced manufacturing.

"We're identifying key technical areas to take forward, especially in construction, digital innovation and low-carbon transport," Kelly says. "It's all based around the skill set we bring from nuclear, and working with local companies to transfer that knowledge into their sectors."

The team are preparing to host events for the D2N2 Growth Hub at iHub, featuring local companies engaged with the Fit For Nuclear (F4N) programme, and working with the LEP and city council to build up the supply chain for the small modular reactor programme.

Nuclear AMRC Midlands is also working with the D2N2 network on the regional skills agenda, supporting apprentices and encouraging local school pupils to study the so-called stem subjects of science, technology, engineering and maths. In March, the centre will open its workshops at iHub to high-achieving pupils aged 13-14 from local schools, offering an introduction to low-carbon nuclear power and a hands-on experience with advanced technologies.

Schools engagement will be a key part of Nuclear AMRC Midlands' work, with a permanent stem corner in one of its workshops. Technologies on offer include a range of programmable robots and desktop 3D printers which will allow children to



Rapid prototyping: 3D printers in the larger workshop.

turn their ideas into reality. "We can go direct from something they've designed to making it in a few hours," says operations manager Ben Sowerby.

Adding innovation

The centre has also invested in a range of advanced 3D printing and rapid prototyping equipment, and is working with SMEs to demonstrate that the technology is much more than a toy. The latest arrival can print components in a range of metals, including 316L steel, Inconel, copper, aluminium and exotic alloys.

"3D metal printing is a new capability for the centre, and we've got work lined up for that," Sowerby says. One early job is printing metal pipe connectors for the Nuclear AMRC's modules research team in Birkenhead – the centre has invested in video conferencing and document sharing to allow seamless working between its regional facilities.

The team are also in discussions about testing another innovative printer which can build parts by combining thermoplastic material with continuous-filament carbon fibre, capable of printing components twice as strong as steel and half the weight of aluminium.

The 3D printers sit alongside rapid 3D scanners in an innovation space within the larger of the two workshops at iHub. This allows researchers to rapidly test innovative ideas by moving from a first idea through to a prototype within a day, and will also allow companies to test ideas or get a first taste of 3D printing. "It'll be an easy way in to our workshops for F4N companies," Sowerby notes.

Also under development in the larger workshop is a digital manufacturing cell, combining virtual reality with motion tracking and data capture to provide a sandbox environment for manufacturing process improvements and systems testing.

"We can merge the real and the virtual at a manufacturing cell or event workshop level, giving you real-world training with virtual assistance, or virtual training with real-world assistance," says senior research engineer Stephen Marr. The cell will be used to simulate and validate a range of design, production and service processes, capturing human interactions and factory flow to help improve productivity.

"Our main focus in the digital team is reducing waste and improving efficiency, all driven by the environmental standpoint," Marr says. "We're making business improvements that also reduce material waste and energy use."

Stem cell: James Twelves, Ben Sowerby and Lauren Dunn of Nuclear AMRC Midlands with NuclearGraduate Callum Huggins and robot demonstrator.

Controls & instrumentation

The second workshop focuses on control systems and instrumentation (C&I), one of the technology areas identified in the Nuclear Sector Deal as requiring additional research infrastructure.

"The industry realised that the UK lacked capacity, knowledge and expertise in this field, so the Nuclear AMRC established this group to build capability and capacity in helping the industry and the supply chain," says Dr Li Li, head of the centre's C&I group.

Li previously worked in the electrical and electronic industry, and is closely engaged with key companies – including Nuclear AMRC members Ultra and Centronic – to identify where innovation can deliver the greatest value.

"The biggest demand we're seeing from industry is around reliable sensing technology, safer control systems and digital transformation," he says. "Some nuclear power stations still use analogue instrumentation, which give you less advantage for effective control, operations and maintenance. We'd like to push the latest proven technology to bring digital transformation to the regulated industry."

The team also aim to help smaller companies assess and develop digital manufacturing capabilities. They are currently working on a pilot project with a Nottingham-based SME which is engaged on the F4N programme.

C&I projects often involve a review of commercially available technology to identify, test and integrate the most appropriate solution for a company's current needs, as well as proposals for new approaches or technologies which could be developed for the longer term.

An initial project for a decommissioning client involves assessing and integrating a variety of smart sensors for long-term condition monitoring and asset management. The team are now looking at self-healing sensors powered by a sustainable energy source, which can operate in harsh environments over a long service life.

Other current projects involve artificial intelligence and machine-learning techniques for asset management and predictive maintenance, drawing on "industrial internet of things" technologies developed in other sectors.

The two workshops will be fully equipped this spring, and the team are planning an industry open day in early summer to showcase the centre's new capabilities, and demonstrate how they can help companies in the Midlands and beyond to innovate and grow.

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Young teams **spark innovation**

Three teams of young professionals from the Nuclear AMRC are preparing for a trip to Paris for the next round of the Spark! contest.

Now in its fifth year, the contest aims to foster an international community of clean energy professionals, and link rising talent with current industry leaders. Entries opened in late 2019 for teams of current and former students of British or French universities to answer this year's challenge: "What would you launch? The next start-up to disrupt the Franco-British low carbon economy."

Three teams of Nuclear AMRC staff and placement students, all aged under 30, qualified in what the contest organisers say was probably the most competitive first round yet.

The first team includes research engineers Arman Zonuzi and Craig Hamer, and Evan Bolle-Jones who was recently appointed as a technical lead after completing the NuclearGraduates programme. Their idea to use old car batteries in a smart grid for local renewable energy storage.

The second team includes Joshua Taylor and Umar Khan, both undergraduates spending a year at the Nuclear AMRC as research assistants, with Elle Wilmot who recently joined the centre as marketing and events coordinator. Their idea is to generate power for charitable organisations from household food waste.

The final team includes current NuclearGraduates Rebecca Lindsey-Halls and Philip Cradduck, and research assistant Beatriz Acevedo Gonzalez. Their proposal involves an electrical solution to avoid emissions from last-mile deliveries.

The teams will join a dozen others during a two-day workshop in Paris in March to develop their ideas with the guidance of industry mentors. Successful teams will then go on to the final *Dragons' Den* style round.

Prizes include exclusive work-shadowing opportunities, and the opportunity for the winners to develop their ideas into projects with the contest's partner organisations. Sponsors include EDF, Rolls-Royce, Framatome, Urenco, Assystem and NNL.

www.thesparkcontest.org

Bright sparks: the Nuclear AMRC teams preparing to develop their low-carbon ideas in Paris.

Manufacturing the **future workforce**

A new report from the High Value Manufacturing Catapult and partners sets out how the UK can build an engineering workforce fit for the future.

UK manufacturers are facing a crisis in recruitment. Surveys show that some 80 per cent of companies struggle to recruit the talent they need to compete, and anticipate increasing recruitment pressures from rapid technological change. Many struggle to access appropriate training to upskill their current workforce.

The *Manufacturing the Future Workforce* report identifies best practice from around the world on how innovation centres can help develop the future workforce, and warns that, without change, the UK's current approach to workforce development will fail to deliver the skilled workers that firms need to succeed.

The report was led by the High Value Manufacturing Catapult, NPL and TWI, with support from the Gatsby Foundation.

"This report demonstrates how the HVM Catapult and other centres of innovation can convene resources and expertise to increase impact on national and local economies," commented Dick Elsy, chief executive of the HVM Catapult. "We are keen to build an alliance with government, industry and education providers to provide the best workforce for future needs."

The report highlights the opportunity for the UK to secure a competitive advantage from its research and innovation communities – but emphasises that government, industry and academia need to work together to equip the UK's future manufacturing workforce with the skills it needs to succeed.

hvm.catapult.org.uk/mtfw

Executive **view**

A year for action

As the UK prepares to host the UN's critical COP26 climate conference in November, our government is promising a Year of Climate Action. Action is exactly what we need.

Cutting our greenhouse gas emissions to net zero by 2050 is a massive technical and economic challenge. We need to take radical action, and we need to act now. If we're serious about reaching net zero by 2050 – and ideally earlier – we need to deploy all available technologies, and invest heavily in new technologies for the longer term.

Last year was the first when the UK produced more electricity from low-carbon renewables and nuclear than from fossil fuels. That's worth celebrating, but there's still a long way to go.

We need to roughly quadruple our low-carbon generation, but the uncomfortable truth is that we're set to lose a large part of current capacity this decade. Nuclear power stations currently provide around a fifth of the UK's electricity, but all but one will shut down by 2030. A decade ago, plans were in place to replace this capacity with new nuclear build but, while EDF Energy is hitting its milestones at Hinkley Point C, no other projects have yet broken ground. That's a big problem for net zero.

As highlighted in the *Engineering Net Zero* report from Atkins, we can't achieve our generation goals with renewables alone. There is no viable energy storage technology which can balance the intermittency of wind, and other alternatives depend on untested technologies such as large-scale carbon capture. These are probably not insurmountable challenges in the long term, but decarbonisation is now a short to medium-term challenge. The clock is ticking, and we need to invest in technologies which we know can deliver.

The main obstacle for nuclear power isn't technological, but financial. Gigawatt-scale nuclear plants require up to £10 billion of upfront investment before they generate any revenue, and financing costs have proven the major obstacle for developers. With interest rates at historic lows, we need to rethink how these critical infrastructure projects can be financed. I look forward to the government's proposals on alternative funding mechanisms in the long-awaited energy white paper.

Beyond the current generation of reactors, we need to develop new kinds of nuclear power plant, especially modular designs which can exploit advanced manufacturing technologies and economies of scale to ensure affordability.

We are part of the UK SMR consortium, led by Rolls-Royce, to develop a more flexible and affordable plant based around proven reactor technology. To make a meaningful contribution to net zero, we need to connect the first commercial unit to the grid by 2030 – most likely on an existing nuclear site in north-west England or north Wales – and then produce up to 10 units a year for the UK and for export.

It's an ambitious programme, but it is achievable. Realising it will establish a new industrial cluster, probably in the north of England, which could be the key to a renaissance of our manufacturing heartlands.

We are the national centre for nuclear advanced manufacturing, but I believe we have an important role to play in the economic development of our home region.

We've already helped make a real impact in South Yorkshire, on and around the Advanced Manufacturing Park. Starting with the original University of Sheffield AMRC back in 2001, we've turned a desolate former coalfield into a world-class cluster of advanced manufacturing. That's brought UKAEA out of Oxfordshire for its new materials testing facility, to work with ourselves and local partners to tackle the manufacturing challenges of commercial fusion power.

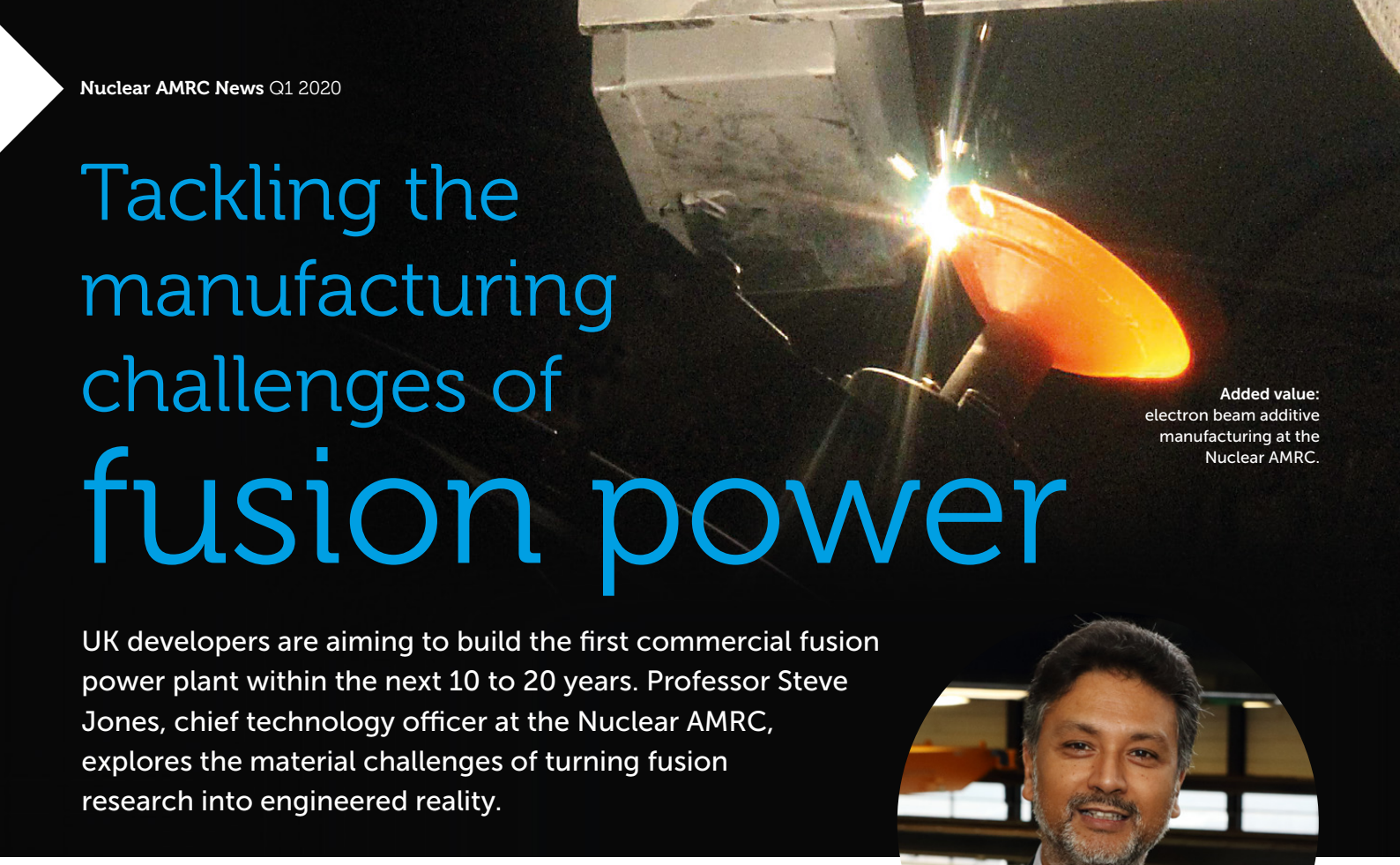
We're now working with local partners in Derby to replicate this success at Infinity Park. Since launching Nuclear AMRC Midlands last spring, we've developed new technical capabilities and engaged with regional businesses in a range of demanding sectors – not least in rail, a sector which also needs massive infrastructure investment to add capacity to our creaking network and improve connectivity nationwide.

Expanding and decarbonising our transport network alongside electricity generation won't be easy, but will offer huge opportunities for manufacturers who can meet the challenge. Achieving our ambitions will require a national effort.

From recent discussions with ministers and advisors, I know that the realisation exists within government that we need major investment in R&D and innovative technologies to grow our economy across the UK and meet our climate commitments. We need close collaboration between industry, government and academia to make this happen. We're ready to play our part.

Andrew Storer, CEO, Nuclear AMRC

Tackling the manufacturing challenges of fusion power



Added value: electron beam additive manufacturing at the Nuclear AMRC.

UK developers are aiming to build the first commercial fusion power plant within the next 10 to 20 years. Professor Steve Jones, chief technology officer at the Nuclear AMRC, explores the material challenges of turning fusion research into engineered reality.

If nuclear fusion is to be a major contributor to meeting the UK's target of net-zero greenhouse gas emissions from 2050, then we need to combine a selection of de-risked advanced technologies with novel manufacturing philosophies to bring commercial fusion to fruition. We need to develop a key suite of "techonomical" solutions which balance technical and cost benefits, providing the supply chain with a compendium of capabilities, and deploying cost-effective manufacturing methods and suitably matured processing technologies with an acceptable design service and performance functionality.

The magnitude of those manufacturing challenges should not be underestimated. Consider the variety and extent of practices which are now being deployed to deliver the international Iter programme in southern France. Such massively complex programmes need to be broken down into more manageably proportioned modules and work packages to maximise engagement with the supply chain and ensure cost-effective delivery to schedule. Developing a modularisation philosophy to meet the needs of fusion will be high on the manufacturing solutions agenda.

We are currently working with UKAEA on an initial feasibility study of modular construction techniques for fusion, as part of the design development of the Spherical Tokamak for Energy Production (STEP), which aims to be the world's first commercial fusion power station. Our team are investigating how the modularisation techniques currently being developed for small and advanced modular reactor designs could be applied to the STEP programme.

This research draws on our ongoing work to develop a through-life modularisation product structure. This is a systematic approach which can be used in the early design process for complex assemblies, to consider factors such as design style, module boundaries, interfacing methods and the degree of modularity required. The aim is to reduce risk in manufacturing and construction of new nuclear projects, and enable on-schedule and on-cost delivery of a modular system which is readily maintainable throughout its required service life including decommissioning.

Material concerns

Arguably the most demanding challenge faced by the engineering community involves the development of comprehensive data about the array of materials which will be needed to build a commercial fusion reactor. Critical components such as first wall lining and divertors have to perform under extreme conditions of heat flux, vacuum and magnetic fields. Fabricating these components from exotic materials will require a more holistic assessment of appropriate technologies and skills.

Suitable materials for these critical components will come from the class of refractory metals, with melting temperatures above 2,000°C. These include niobium, molybdenum, tantalum, tungsten, rhenium and their alloys. For fusion, we need to identify metals which can avoid problematic radioactive isotope formation, resist ion bombardment, avoid embrittlement, and have good thermomechanical stability with limited tritium sequestration. These demands considerably narrow the choice of material.

We also need to consider advanced materials beyond these metals, with cermets (ceramic-metal composites) and other ceramic composites potentially providing additional benefits (see box). Qualifying these for safety-critical fusion applications will require significant advances in integrity assessment techniques, such as the use of graphene sensors for defect detection and predictive maintenance in composite structures.

Tackling these challenges will be the job of UKAEA's new material testing facility, currently under construction at the Advanced Manufacturing Park. When it opens later this year, the new UKAEA facility will develop and test fusion materials and components. These materials, including novel metals and ceramics, will be tested and evaluated under simulated reactor conditions.

Much of the research will focus on joining techniques for these materials. We are seeing a lot of interest in advanced power beam welding processes, including electron beam and laser technologies, with integral inspection systems. These are capable of producing and inspecting autogenous and heterogeneous welds with reduced cracking susceptibility, residual stress and distortion of complex geometries, while simultaneously determining the joint's integrity.

Some of these power beam techniques, such as electron beam welding, require a vacuum so are currently deployed within a vacuum chamber. There is currently a lot of interest in local vacuum techniques which will allow single-pass welds of thick sections without needing a vacuum chamber large enough to contain the entire assembly. We are working with industry partners on various approaches to local-vacuum electron beam welding, in projects funded by the UK government through the Nuclear Innovation Programme, including a new collaboration led by Sheffield Forgemasters (see p13).

Fusion components will also require dissimilar metals and materials to be joined, calling on solid-state bonding techniques such as diffusion bonding, ultrasonic bonding, electro-magnetic pulse bonding and hot isostatic pressing.

The machining of such materials will rely on specialised techniques, such as supercritical carbon dioxide cooling methods to support tool life and metal removal rates. We are already working on these techniques, but developments in machining technology do need to be studied further to improve confidence in product integrity and provide a balanced approach to assessing and utilising the optimum fabrication solution.

Additive, AI & other innovations

As an alternative to traditional fabrication and machining, we're also seeing a lot of interest in additive manufacturing and other near-net shape forming techniques.

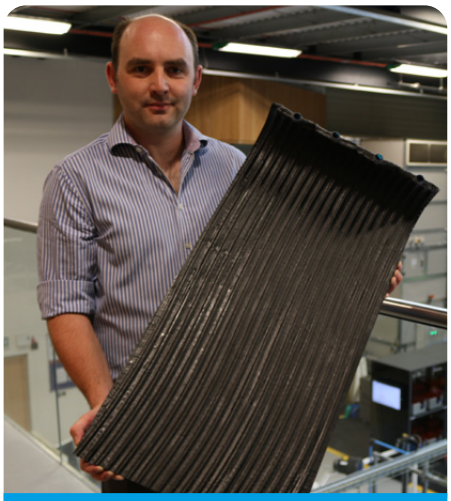
Direct energy deposition techniques, which combine welding tools with automated control to accurately deposit metal wire or powder, are already used in aerospace and other industries, but will need further development for fusion applications. Early research has shown that depositing tungsten and niobium in their pure form within high quality inert atmospheres can still result in problems such as through-thickness cracking and internal microfissures.

The use of near-net shaped forming exploiting superplastic and solid-state techniques should also be explored further. These can produce dissimilar metal bonds and functionally graded components with maximised inherent thermophysical properties to supplement the part's performance conditioning. Here, it may be possible to produce artefacts of a tailored chemistry to facilitate integral features that can enhance fabrication requirements such as improved stiffness and inspectability.

Advanced numerical simulation techniques will allow designers to push the envelope on component performance, potentially including predictive analytics that can exploit a compendium of self-diagnostic neural network algorithms. We should also look to develop and adopt tactile and remote in-process inspection methods using ultrasonics, vision systems, advanced electromagnetic acoustic transducers and airborne acoustic system analysis. These should be coupled with advances in deep-learning artificial neural networks which will need to be embedded seamlessly within a production schedule.

Bringing fusion power from the physics-based research world to engineering-based commercial reality will require a host of advanced manufacturing technologies and, no less vitally, an agreed adoption of suitable design and manufacturing codes. While the Iter programme has adopted the well-established AFCEN codes, future commercial fusion projects will need the development of manufacturing codes specific to fusion reactor technology. Such codes will only become suitably effective once service data have been analysed.

A version of this article first appeared in *Nuclear Engineering International*.



Safety blanket: AMRC research engineer Steffan Lea with the composite prototype.

Weaving an alternative

Woven ceramic composites could provide a lightweight alternative to the metal breeder blankets which capture the energy from fusion reactors.

The breeder blankets being tested for the Iter fusion project in France are made from steel, with a complex structure of small double-walled tubes which require welding and inspection. Each section weighs up to 6.4 tonnes.

One potential alternative is silicon carbide composite, a lightweight material which can be woven around the cooling tubes and 3D-printed features. As well as simplifying construction and maintenance, the composite can also allow higher operating temperatures.

UKAEA called on composite specialists from the University of Sheffield AMRC, the Nuclear AMRC's sister centre, to test the feasibility of this alternative approach. The team produced a prototype blanket section made from carbon fibre reinforced polymer with integrated cooling channels and pockets for tubes.

"This successful project has been an excellent first step in demonstrating alternative structural materials and manufacturing routes for scalable fusion reactor components," said Dr Elizabeth Surrey, UKAEA head of technology.

Chocolate science and aerospace repair

A new video for an international research collaboration into additive repair shows how chocolate can help teach school children about engineering and science.

The video features Dr Rahul Mandal, research associate at the Nuclear AMRC and winner of The Great British Bake Off in 2018. Mandal regularly works with local schools to encourage students to study science, technology, engineering and maths-based subjects – and welding with chocolate is a great way to get their attention.

The welding and additive manufacturing technologies being developed by the Amos project are rather more advanced, and could be used by the aerospace industry by the time today's primary school pupils are planning their careers.

The Amos project is a collaboration between nine companies and research institutions across Europe and Canada, led by the Nuclear AMRC.

Since the project's launch in 2016, the Amos consortium have investigated a range of additive manufacturing techniques which combine welding tools with automated control to accurately deposit and melt metal powder or wire. Many of these techniques are already used in aerospace and other industries to build new parts to near-net shape.

Amos has developed these techniques to repair and remanufacture aerospace components such as turbine blades and landing gear. This could significantly reduce the time and cost of maintenance, while reducing material waste and extending the life of expensive components.

The Nuclear AMRC's additive manufacturing team, headed by technology lead Udisien Woy, focused on additive repair with the aerospace alloy Inconel. The team have completed extensive trials using two additive processes – gas tungsten arc welding with Inconel wire, and diode laser welding with powdered metal – and analysed the material performance of hundreds of repairs.

The centre's inspection specialists also worked with intentionally damaged samples produced by the industrial partners to help develop innovative scanning technologies.

Amos is supported by the European Horizon 2020 programme and Canadian funding agencies CARIC and NSERC. Results from the project will be shared with the supply chain.

To watch the video: **namrc.co.uk/centre/amos-chocolate-video**

Research highlights

Recent publications by Nuclear AMRC researchers.

Engineers who demonstrated automated grinding techniques for nuclear components (see last issue) have published a detailed account of vision-assisted finishing of friction stir welded joints.

Friction stir welding can cause flash of up to several centimetres thickness, which is currently removed manually. As part of the European Coroma project to develop intelligent robot technologies, the team developed a system combining a visual scanner and grinding tool with digital manufacturing technologies developed by the other Coroma partners.

In trials on square tubes used in nuclear fuel assemblies, the system was able to automatically generate tool paths and remove the flash with no human assistance. The final surface roughness more than met industry requirements.

The Nuclear AMRC's Ozan Gurdal, Ben Rae and Arman Zonuzi presented the project at the 19th Machining Innovations Conference in Hanover, with a paper to be published in *Procedia Manufacturing*.

www.journals.elsevier.com/procedia-manufacturing

A combination of supercritical carbon dioxide coolant with minimum quantity lubrication (MQL) can improve surface integrity in high-feed milling of the aerospace alloy Ti-6Al-4V.

A Nuclear AMRC team including Przemyslaw Litwa, Dr Krystian Wika, Arman Zonuzi and Carl Hitchens studied the influence of cutting conditions on surface integrity when using a standard oil coolant, supercritical CO_2 alone, and CO_2 with MQL. After extensive cutting trials on the centre's Starrag HEC1800 horizontal machining centre, the team carried out extensive microstructural analysis and measurements of surface roughness and microhardness.

The combination of supercritical CO_2 and MQL provided the most effective cooling, allowing higher cutting forces while inducing less heat in the in the workpiece. There was no deterioration of surface integrity or evidence of microstructural changes. Deterioration was observed with oil coolant.

The team presented their research at the 15th International Conference on High Speed Machining in Prague, with full details published in *Modern Machinery Science Journal*. The research was funded by the High Value Manufacturing Catapult.

DOI: 10.17973/MMSJ.2019_11_2019053

Landmark project for **Sheffield Forgemasters**

The Nuclear AMRC is working with Sheffield Forgemasters and partners to develop electron beam welding techniques for civil nuclear assemblies.

Forgemasters, a founding member of the Nuclear AMRC, has secured £8 million funding from the project from the government's Nuclear Innovation Programme. This is the largest single grant to date from the programme, and Forgemasters' largest ever collaborative R&D project.

The 18-month project will explore the industrialisation of electron beam welding in civil nuclear assemblies. Integrating welding into the manufacturing process could deliver material improvements and vast reductions in manufacturing time and cost.

"This is a landmark project for the UK, building on three years of work we completed in partnership with Innovate UK, to refine the basic science of electron beam welding in nuclear applications," says Jesus Talamantes-Silva, Forgemasters research director. "The implications of accelerating this technology for civil nuclear power are significant, but could also benefit other sectors including defence, offshore and petrochemical industries."

The company will install an electron beam welder capable of welding three-metre diameter cylinders under localised vacuum and without traditional welding preparation, and test on several grades of steel alloys suitable for fission and fusion applications.

Sheffield steel: Forgemasters offers a host of advanced capabilities.

Electron beam welding can reduce the time for circumferential welding of pressure vessels from around 150 days using traditional methods, to just 10 days. As a technology demonstrator, the team will produce a full-sized small modular reactor pressure vessel.

"Through the science that we have already refined, we will be able to produce safer, stronger components for the next generation of nuclear power, with lower costs and vastly reduced production times," Talamantes-Silva says.

The consortium also includes welding specialists TWI, CVE and Arc Energy, as well as The University of Manchester and University of Cambridge.

www.sheffieldforgemasters.com

Offshore funding for **AI research**

Global Energy Group and the Nuclear AMRC are investigating artificial intelligence for fabrication, after securing funding from a new partnership focusing on the renewable energy sector.

The project is one of seven supported by the first funding competition from the Offshore Wind Growth Partnership (OWGP).

The Nuclear AMRC will act as delivery partner for the Global Energy Group's proposal to apply artificial intelligence and machine learning to renewables fabrication.

Based in Inverness, Global Energy Group provides construction, maintenance and other services to clients across the energy sector.

Two other projects funded under OWGP's call for advanced manufacturing research also involve centres within the High Value Manufacturing Catapult. The National Composites Centre will work with Cedeco to develop composite tools, and the University of Sheffield AMRC will work with Magnomatics on robotic placement of large rotor magnets.

"This was a very competitive process and we received a high number of quality applications, totalling almost £2 million in project costs, demonstrating the huge opportunities to maximise the economic benefits of our world-leading position in offshore wind," said Andrew Macdonald, OWGP programme director.

OWGP was launched in June 2019 as part of the Offshore Wind Sector Deal, with a budget of £100 million over 10 years. Delivery is managed by the Offshore Renewable Energy Catapult, with support from specialist partners.

owgp.org.uk

Adding value for members

Sean Murphy joined the Nuclear AMRC in January to make sure that the centre is delivering real value to its members. *Nuclear AMRC News* asked him to introduce himself.

I have worked in sales, customer service and business development for my entire career. For the past 20 years, I have had various roles in the UK manufacturing industry, mainly involved in the design and manufacture of heat exchangers and pressure vessels. I have worked within large organisations and SMEs, which gives me a broad understanding of the challenges facing industry. I have had an interest in nuclear power generation for many years, and my roles have allowed me to gain a more in-depth understanding of the sector.

My role at the Nuclear AMRC is as strategic relationship manager, with a focus on the centre's membership programme. My aim will be to enhance the experience of existing members. and encourage more companies to consider and realise the benefits of working with us. Crucially, I believe the relationships should be around achieving best value for both members and the centre.

I'd like to see a larger and more diverse membership of tier one and two companies, collaborating with us to carry out R&D, improvement and pre-production projects.

We always aim to tailor membership as much as we possibly can to a company's needs. Ultimately, the centre's members inform the direction we take, and make sure we're relevant to industry. The more members we have, the more value we can add to industry.

Members benefit from access to our research board and our previous research findings, and to the industry and technical expertise and knowledge we have here at the centre, and can help shape the direction the centre goes in future.

I also want to build stronger relationships with the companies engaged on our Fit For Nuclear supplier development programme, and help them to work more closely with our manufacturing innovation teams. We want to be the people they call when they first identify a need or have an idea.

I strongly believe that UK companies of any size can and should play a bigger role in the nuclear industry. The centre's role is critical to getting this message out and supporting manufacturers on their journey. The sector has a unique complexity, which we understand well and can offer valuable support and guidance.

To learn more about the benefits of membership, contact: **sean.murphy@namrc.co.uk**

New agreement to support **Bradwell supply chain**

The Nuclear AMRC has signed a new agreement with Chinese nuclear group CGN to help develop the UK supply chain for the HPR1000 reactor.

The memorandum of understanding (MOU) between the University of Sheffield and CGN's UK subsidiary General Nuclear International sets out how the organisations can work together to develop the UK supply chain and support production of the HPR1000 for UK deployment.

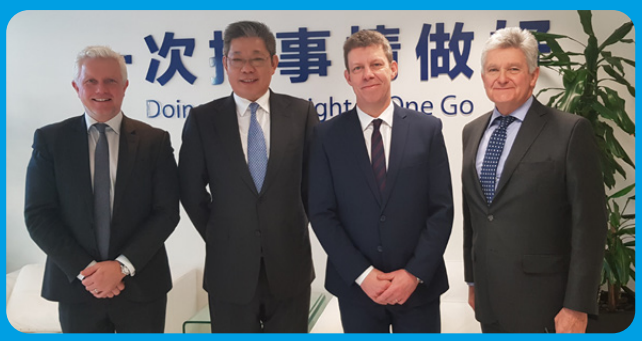
CGN plans to build its HPR1000 reactor at Bradwell in Essex, in partnership with EDF Energy. The 1170MW pressurised water reactor has completed the second phase of the UK's generic design assessment, with final approval expected around 2022. The first HPR1000 power stations are now under construction in China.

The Nuclear AMRC and CGN signed an initial MOU in June 2018 to explore how they could develop the UK supply chain for Bradwell, and strengthen links between manufacturers in the two countries.

Nuclear AMRC CEO Andrew Storer and Professor Koen Lamberts, University of Sheffield Vice-Chancellor, met with CGN UK CEO Zheng Dongshan and COO Robert Davies in February to discuss areas for collaboration, including manufacturing research and workforce skills.

"Our relationship with CGN continues to develop, and this new agreement will help UK manufacturers make the most of the opportunities at Bradwell B and beyond," Storer says. "By working with CGN, we can identify where the UK supply chain can add value, and help companies to qualify and win work in the HPR1000 programme."

en.cgnpc.com.cn



International understanding: Andrew Storer, Zheng Dongshan, Koen Lamberts and Robert Davies

F4N
Fit For Nuclear

Hinkley Point win for **GR Carr**

Mechanical engineer GR Carr has secured its first order for Hinkley Point C, less than two years after being granted Fit For Nuclear.

The Essex-based firm won the contract for four large stainless structural steel fabrications which will be incorporated into the nuclear island at EDF Energy's new build project in Somerset.

The order was placed by Bylor, the joint venture between Bouygues TP and Laing O'Rourke which is EDF's lead contractor for civil works at Hinkley Point.

"The opportunity to tender came about as a result of networking with companies that we deal with who were already part of the Hinkley Point supply chain," says quality manager Dave Jefferies. "Having gained our F4N status in early 2018, we initially went through the pre-qualification process with Bylor at the end of 2018.

"The benefits of having gone through the F4N programme were huge, as we were able to answer their questions knowledgeably and with a degree of confidence that we simply wouldn't have had without all that we had learned from our F4N advisors, Kevin Shepherd and Dr John Coleman."

GR Carr entered the Fit For Nuclear programme in late 2015, to prepare for opportunities in nuclear new build and to drive business improvements across the company. The firm has served quality-critical markets such as petrochemical, oil and gas, and energy for almost 50 years, providing piping and structural steel fabrications and maintenance services from its 4.5 acre site in Basildon.

Following the initial F4N assessment and gap analysis, the firm worked through an action plan to deliver significant improvements and raise standards all round. To embed nuclear safety culture, the company recruited a new safety manager with 14 years of experience working in a nuclear power station, and gave operational staff more responsibility for driving improvements in quality, health and safety.

GR Carr also focused on training and development for its 90-strong workforce, with personal development plans for all staff including core training in continuous process improvement methods, and advanced qualifications for key engineers. In late 2018, its efforts were rewarded with the SME of The Year Award from the Engineering and Construction Industries Training Board.

Following its first major contract at Hinkley Point, GR Carr is now targeting other nuclear opportunities. The firm is already engaged with the Sizewell C supply chain team preparing for EDF Energy's next new build project, some 80 miles up the coast, and will be well placed for work at CGN's proposed development at Bradwell in Essex.

"Everyone at GR Carr has been heavily involved with the cultural changes that have taken place over the last four years, and we are over the moon to be able to share this key milestone in our F4N journey," says Jefferies.

grcarr.com

Joining the nuclear supply chain: GR Carr has invested in skills for staff.

F4N
Fit For Nuclear

A&P Falmouth sets sail for new markets

A&P Falmouth is targeting fabrication opportunities at Hinkley Point after being granted Fit For Nuclear.

Deep waters: A&P Falmouth's complex.

A&P Falmouth in Cornwall is the UK's largest ship-repair complex, and one of the world's largest natural deep-water harbours. It is part of A&P Group, which operates seven dry docks at four locations around England.

As well as working on ships of up to 100,000 tonnes, the facility produces large fabrications for the oil and gas and offshore renewables sectors. It is also home to one of the UK's most comprehensive machine shops, capable of working on large components such as shafts of up to 12 metres. The company has over 270 full-time employees, and can have several hundred sub-contractors on site at busy times.

While A&P's North-East facilities have worked on the submarines programme, the group hasn't previously worked in civil nuclear. With the new build programme kicking off at Hinkley Point C in Somerset, the Falmouth team saw the opportunity to enter a new market.

"We see opportunities to provide large volumes of carbon steel fabrications for secondary support structures, gantries, walkways, electrical and pipe supports," says Steve Jones, managing director for operations and site director. "These are the kind of structures we've been fabricating for a long time."

Group HSEQ director Kevin Peart worked with F4N industrial advisors Mark Knowlton and Stuart Hughes to take the Falmouth facility through the journey from assessment to granting. With A&P's extensive experience in highly regulated and quality focused industries, the journey was a smooth one.

"The F4N process has blended very well with our integrated management system, which is certified to ISO 9001 and 14001," Peart notes. "We found that F4N has allowed us to measure all the good work we've done already. We get audited by an awful lot of external organisations, and going through the F4N process has helped us improve a lot of our internal procedures on the design and risk side."

F4N also helped the team develop its already high health and safety standards to meet the expectations of nuclear customers, with investment in training across the organisation. "The safety culture was relatively straightforward because of work we'd already done," says Peart. "We

had an internal programme dealing with behavioural safety, and the training we've had on nuclear safety culture has fitted in really well with what we're doing."

The programme also supported a major overhaul of the fabrication workshop, with improvements to the working environment and electronic communication boards to share news and strategic information with staff. The firm also brought in external trainers to embed 6S lean manufacturing principles in its day-to-day work.

"On the first course, we had about 40 people from senior directors to shopfloor operators," Peart says. "It was very clear to everyone what the 6S approach is, and we've embraced that, setting up things like cleaning stations throughout the fabrication shop and improving lighting. It's given everyone a positive feeling."

Hughes agrees that A&P's F4N journey has made a clear difference to the site and the workforce. "When I first visited the Falmouth site in September 2018, I could see there were good foundations to build on, with manufacturing facilities and capabilities that are not common in the South West and were likely to be of interest to the new nuclear build team at Hinkley Point C," he says. "The workshop was an area of concern, though – with a long history, it was dark and in need of some TLC. The company's F4N champions have done an excellent job in transforming not only the appearance of the workshop area, but also the engagement of the staff."

A&P Falmouth was granted F4N in October 2019, and is now engaged with a number of EDF Energy's top-tier suppliers for Hinkley Point C. The team have recently provided weld inspection and rectification services on a jetty for the site, and are confident of their ability to secure larger work packages.

"It's an industry that really requires the highest standards of quality and health and safety, and we understand that," says Jones. "The next step is to ensure that we fully establish ourselves within the industry."

The firm's F4N journey also puts it in a better position to serve other sectors, Peart notes: "We're always working with gas and oil and renewables sectors, and they also require a good standard of quality and health and safety. I definitely think F4N is improving those standards."

www.ap-group.co.uk/facilities/ap-falmouth

Congratulations to the latest companies to be granted Fit For Nuclear

These companies have benchmarked their performance against the standards demanded by the nuclear industry's top tiers, and driven business improvements.

Hardstaff Barriers supplies security solutions including hostile vehicle mitigation, perimeter fencing, concrete barriers and gates, with experience in edge protection and delineation for nuclear construction projects including Hinkley Point C and Sellafield.
www.hardstaffbarriers.com

Heatsense Cables is a leading provider of specialist thermocouples and high-performance cables for extreme environments, with clients in the nuclear, oil and gas, aerospace, automotive and medical markets.
www.heatsensecables.co.uk

Kloeckner Metals UK is the UK's largest mill-independent multi-metal stockholder and distributor, offering a diverse range of ferrous and non-ferrous products sourced from reputable and accredited mills across western Europe.
www.kloecknermetalsuk.com

Congratulations also to the F4N companies which have renewed their status three years after initial granting.

- **C E Turner Engineers**
- **Evenort**
- **Exyte-Hargreaves**
- **Fort Vale Nuclear**
- **GA North West**
- **Graham Hart**
- **Horstman Defence Systems**
- **Legrand Electric**
- **Maher**
- **Manthorpe Group**
- **NTR Ltd**
- **Outokumpu Stainless Distribution**
- **Strata Technology**
- **TMB Patterns**
- **WES**

For details of all F4N-granted companies:
namrc.co.uk/services/f4n/companies

Atkins calls for sea change to **achieve net zero**

Engineering group Atkins has called for significant investment in every area of low-carbon energy production to meet the UK's target for net-zero emissions.

***Engineering Net Zero*, a detailed technical report released by Atkins in January, details the opportunities and challenges in nuclear, renewables, hydrogen and carbon capture technologies.**

Reducing net greenhouse gas emissions to zero by 2050 will require a quadrupling of low-carbon electricity generation, the report notes. Fossil fuels accounted for less than half of the UK's generation in 2019 for the first time, but total demand for electricity is likely to double as transport and heating are electrified.

"The green future we aspire to is possible," commented Chris Ball, managing director for nuclear and power at Atkins. "However, it requires a sea change in how we approach our energy system and the scale of investment required. Government has set the target and, working in collaboration with industry and academia, we can meet the ambition. But it requires an unprecedented level of commitment, investment and co-ordination to drive forward a programme of works."

While renewables including offshore wind can play a major role in low-carbon generation, there is no viable energy storage technology which can resolve the challenges of intermittent generation.

The only viable sources for firm low-carbon power in the UK are nuclear, or gas turbines combined with carbon capture and storage (CCS). With negligible current capacity for CCS in the UK, the report notes that the least-cost route to net zero could require "considerably more nuclear than is currently being considered".

Eight nuclear power stations currently provide around a fifth of the UK's electricity, but seven will shut down by 2030. Only three replacement plants are in active development, the report notes, with current government proposals for reaching net zero curtailing nuclear in the mid-2030s.

New designs of small modular reactor (SMR) and advanced reactors could play a role, but the capability to deploy these will be seriously threatened if gigawatt-scale new build is curtailed.

Modular reactors are designed to reduce the cost of new build by enabling the kind of efficiency gains achieved by other industries where complex technologies are consistently built by the same organisation in the same context.

Atkins is part of the UK SMR consortium to develop a 440MW power station, with the first commercial unit in operation in the early 2030s. The consortium is led by Rolls-Royce and also includes the Nuclear AMRC, Assystem, BAM Nuttall, Laing O'Rourke, Wood, NNL and TWI.

For the full report: **explore.atkinsglobal.com/engineeringnetzero**

Low-carbon record for Hinkley Point

EDF Energy's team at Hinkley Point B celebrated a low-carbon milestone in January.

The plant has now generated over 300 terawatt hours of low-carbon electricity – more than any other power station in the UK.

In 1976, Hinkley Point B became the first advanced gas-cooled reactor to connect to the national grid. Its two reactors now generate around 965MW – enough for 1.8 million homes at current consumption – and are scheduled to enter decommissioning in 2023.

The first of two 1.6GW EPR reactors at Hinkley Point C is on schedule to join the grid in the mid-2020s, with the second around two years later. The reactors are expected to operate for 60 years.

Virtual tours at the **Big Bang Fair**

The Nuclear AMRC will offer young people a virtual tour of its research factory at this year's Big Bang Fair.

The centre is exhibiting at the annual event, held at the NEC over 11–14 March, which aims to inspire young people to develop a career in science and engineering. Last year, the fair welcomed 80,000 visitors including 62,000 young people for interactive activities, workshops and shows. As the largest science, technology, engineering and maths celebration fair in the UK, it's a fantastic opportunity for young people to get their hands on the latest technology and discuss innovative ideas with working scientists and engineers.

Young engineers from the Nuclear AMRC will share virtual reality headsets to allow children to safely explore the Nuclear AMRC workshop, the opportunity to build a model reactor using 3D-printing pens, and a glovebox challenge to test how well visitors can handle objects in a high pressure environment.

www.thebigbangfair.co.uk

Like being there: research assistant Beatriz Acevedo Gonzalez tests the VR tour of the Nuclear AMRC workshop.

Some of the events that the Nuclear AMRC will be attending or supporting in the coming months.

Diary **namrc.co.uk/news/events**

DIT Civil Nuclear Showcase

3–4 March 2020, London

Highlighting the world-leading capabilities of the UK nuclear sector, the Department for International Trade's annual event returns with networking opportunities and insight into global market opportunities.

www.events.great.gov.uk/cns2020

TotalDecom Expo 2020

31 March – 1 April, Manchester

A cross-sector supply chain exhibition, presentations and one-to-one appointments with industry leaders, to help suppliers network and diversify into new decommissioning markets.

www.totaldecom.com/next-event/totaldecom-expo-2020

Decom2020

17 June, Telford

The Nuclear Industry Association offers networking opportunities and the latest industry information on decommissioning challenges in the UK and abroad. The conference is supported by the NDA, which holds its supply chain event at the same venue on 18 June.

www.niauk.org/event-listing/decom2020

www.decommsupplyevent.co.uk

World Nuclear Exhibition

23–25 June, Paris

The leading marketplace dedicated to the global civil nuclear community, bringing together around 730 organisations from around the world. The Nuclear AMRC will host a supply chain showcase as part of the UK Pavilion.

www.world-nuclear-exhibition.com

Work **with us**

The Nuclear AMRC is here to support manufacturing companies, from SMEs to global giants, which are seriously interested in winning business in the nuclear sector.
If we can help your company, we want to hear from you.

We help manufacturers through **supply chain development** and **innovation**.

We can work with you to raise your quality, capability and cost competitiveness to meet the needs of the global nuclear industry.

And we can develop world-leading manufacturing processes and technologies. We have the production-scale facilities and the manufacturing expertise to help you improve cycle time, reduce lead time, improve quality and reduce costs.

Our capabilities and services are open to all UK manufacturers. We provide a responsive service to help you solve your manufacturing challenges and win new work.

We also offer full membership, giving you access to our generic projects and the opportunity to determine our core research.

To find out more about how we can help you win work, contact the Nuclear AMRC business development team:
business@namrc.co.uk

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Tier 1 members:

CAMMELL LAIRD · Canadian Nuclear Laboratories · cavendish nuclear · EPRI ELECTRIC POWER RESEARCH INSTITUTE · framatome · HEXAGON MANUFACTURING INTELLIGENCE · TWI Welding · NDA Nuclear Decommissioning Authority · NIA Nuclear Industry Association · Rolls-Royce · SHEFFIELD FORGEMASTERS INTERNATIONAL · TSP ENGINEERING · ULTRA · Westinghouse

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