

wood.

## Reactor Services

A lifetime of support



Wood is a global leader in project delivery, engineering and technical services, providing efficient, integrated solutions across the asset life cycle in multiple sectors. We are proud of our rich heritage which underpins our unrivalled breadth and depth of capability. We employ people with the brightest minds and the sharpest skills, who use our leading-edge technology to help our customers succeed.

Our differentiators include our extensive range of services, the quality of our delivery, the passion of our people and our unique culture. True to our values, we work in an open and transparent way; a committed partner to our customers, supply chain and the communities we work with.

Our values set the tone for what is important in our business, they are the essence of our identity and fortify everything we do.

### Care

Working safely with integrity, respecting and valuing each other and our communities

### Commitment

Consistently delivering to all our stakeholders

### Courage

Pushing the boundaries to create smarter, more sustainable solutions

**160+**

year heritage

**60,000**

employees

**60+**

countries



"Each and every individual in our business has the ability to make a significant impact to our safety delivery. Safety is what we care about most and being safe means looking out for yourself and showing care for your colleagues. Keep safety at the heart of every conversation you have."

**Robin Watson,**  
Chief Executive



# Playing a critical role in nuclear projects across the world

We have been at the forefront of the nuclear industry for more than 60 years. We are passionate about nuclear energy, its role in the world today and in the future.

Our reputation is founded on the very best technical expertise and the reach to deliver this knowledge locally to projects across the world. Our approach is highly collaborative and based on long-term relationships. We are a trusted partner for customers on five continents.

## **Our people write the world's standards**

At the very heart of our business are our people, who include international technical leaders in their fields. We choose to be technology independent so that we can bring our partners the very best-in-class experience of different reactor types and vendors. We also own and operate the UK's largest independent nuclear research and testing facilities with 12,000m<sup>2</sup> of labs and test rigs plus remote handling and inspection technology.

## **Technical excellence breeds innovation and assurance**

By combining engineering and technical excellence with innovation, research and development, we have the ability to solve the world's most complex nuclear problems safely and cost-effectively.

We were involved in the original design, construction and commissioning of the UK's fleet of advanced gas-cooled reactors and the Sizewell B PWR. We are EDF Energy's lifetime partners for fleet-critical projects, life extension support and transition to end-of-life, having already helped to achieve an average extension of nine years at the AGR stations.

Our relationship with these NPPs and their operator is truly one of the most enduring and productive partnerships anywhere in UK industry. Our test rig and laboratory facilities are integral to our work on addressing asset-life limiting challenges and developing solutions to emergent and predicted issues at our customers' nuclear power plants.

We are strategic lifetime partners for fleet-critical projects and life extension support to EDF Energy. We have played a key role in every UK new nuclear build project

# Fleet-critical life extending solutions

Extending the operation of complex nuclear assets beyond their original design takes a deep understanding of nuclear engineering and the systems that underpin it.

Our experts work across a huge variety of science and engineering-related projects. This ensures we have the experience and the expertise to design and implement solutions to extend the life of ageing nuclear power plants and equipment.

We have supported civil nuclear power generation since its pioneering inception in the UK, some circa 60 years ago. Our world-leading Generation Services team helps underpin the safe, reliable and economic operation of nuclear assets throughout the full operating lifecycle. Specifically, we focus on safety (including safety cases, modelling and simulation and safety systems), the management and maintenance of plant and equipment; plant life extension; technology and innovation; ageing and obsolescence; and output optimisation.

In the UK, Wood adds significant value supporting EDF Energy in delivering core and investment work, providing solutions for and delivering fleet-critical projects, and in strategic lifetime partnering.

As architect engineer for the UK advanced gas-cooled reactor (AGR) fleet and as one of the organisations that designed and commissioned Sizewell B, Wood has intrinsic plant knowledge covering reactor systems, balance of plant, life-limiting components, plant technology and performance.

Our support has played a major role in securing lifetime extensions of up to 10 years on the UK's 14 AGRs. As well as specific knowledge which supports the primary circuit codes and software, we maintain and manage original material samples and records for reactors and boiler components. Our test and laboratory facilities are unique in the UK and we are EDF Energy's largest UK research provider.

In France, we have supported EDF SEPTEN with:

- probabilistic safety analysis of external hazards, including seismic activity and flooding, to support the justification to safety authorities for the life extension of NPPs;
- qualification and design of electrical equipment, covering new build and modifications on the existing fleet, including justification for renewing equipment qualification during the life extension process;
- ageing management tests on various components at our laboratories



## Hot box dome

A rise in temperature on the hot box dome surface (a steel dome that separates coolant gasses) was restricting generation output on reactors at Heysham and Hartlepool power stations. A joint EDF Energy and Wood team found a unique approach, which involved drilling bleed holes, remotely, within the reactor control rod guide tubes that go through the dome. Working collaboratively, Wood developed, designed and manufactured complex equipment to detect the dome height, drill and weld remotely under high temperature and radiation conditions.

A full-scale, quarter section mock-up test rig was quickly constructed within Wood's facilities to conduct trials, provide operator training and prove to regulators the technique would work and was safe. The technique achieved temperature reductions in the immediate area around the drilled locations, as well as cooling across the dome generally, enabling the reactors to return to safe operation at 90% of capacity.

## Innovation in inspection and upgrade

Wood was involved in two significant projects with EDF Energy, which enabled the inspection and upgrading of the boiler closure unit (BCU) at the Heysham and Hartlepool NPPs in the UK. The works were split into: BCU inspection and re-greasing; and BCU instrumentation.

Working 24 hours a day over several months, our team developed a number of innovative techniques for inspection, measurement and re-greasing within the BCUs, bringing the reactors back online ahead of anticipated timescales. We led the project, managed the supply chain and were responsible for the design, build and commissioning of approximately 8,000 new instruments for controlling and monitoring key parameters of the newly installed BCU bands, along with a bespoke bundle profile measurement tool.

A lifetime partner and the largest R&D provider to EDF Energy in the UK, we were principal designer and architect engineer for the UK's first and second generation reactors.

# Managing ageing assets

Wood has deep experience of helping customers to optimise performance of aging assets and to support equipment reliability. This has been gained in many industries, from nuclear engineering to petrochemicals and mining.

Our lifecycle asset management service provides solutions to address the effect of ageing on systems, structures and components, using a combination of component condition assessments and plant lifetime assessments. It enables our customers to improve system reliability, extend the useful life of plant and reduce the lifecycle costs of ownership.

We also provide ageing management support to our customers through ageing management audits, deep dives and the production of safety factor documents in line with PAS55 and NS2.10 International Standards (IEEE).

## A unique combination of expertise and experience enables us to:

- develop our understanding of baseline equipment capability and condition;
- identify, evaluate and select options for equipment management;
- evaluate existing maintenance regimes and optimise future activity;
- implement solutions from replacement through to re-engineering and effective spares management

Our approach addresses both planned and unplanned maintenance, significantly reducing failures and unplanned downtime, shortening the time from an incident to the restoration of operations.

This extends from developing the investment strategy through to implementing the strategy on diverse systems.

We also help our customers to define plant condition and operation through three-yearly safety system reviews and ten-yearly periodic safety reviews. These help to demonstrate the case for safe, continued operation of plant – a crucial requirement of nuclear plant regulators.

## Wood's comprehensive support on plant equipment and maintenance includes:

- support on maintenance and equipment reliability;
- a broad-based engineering, technical and safety case capability deployed across a range of projects and programmes;
- project management capability deployed at NPPs;
- boiler modelling, plant chemistry, materials and corrosion including operation and maintenance of specialist test rigs;

- graphite inspection data analysis that operates as a 24-hour service to support outage inspections;
- graphite stress and damage tolerance code development and analysis teams that support lifetime safety cases including keyway root cracking;
- core teams in support of obsolescence in high-integrity controls and instrumentation;
- code development and maintenance, using world-class high-temperature materials facilities to carry out the R5 assessment procedure for the high-temperature response of structures and the R6 procedure for assessing the integrity of structures containing defects;
- engineering development of novel solutions – rapid deployment of a cradle-to-grave service that has supported many fleet-critical projects. This covers engineering, safety case development, remote operations, inspection development, training of site teams utilising bespoke rigs, and deployment to site;
- inspection validation and qualification of in-service inspections;
- expert knowledge of the investment delivery process and provision of site project management services



Wylfa Nuclear Power Station, Anglesey, North Wales

Reachback into the wider Wood organisation enables us to draw on additional expertise, newly developed technologies and leading edge applications which have proved themselves in the oil and gas and power and process industries. Examples include products designed to reduce vibration in piping systems, a first-of-its-kind online software tool to identify vibration risks, and post-processing software which reduces weeks of data analysis time to a few days.

## Fuel cycle management

Wood supported Magnox to achieve a nuclear first at the Wylfa 1 reactor by enabling it to be shut down having used up all of its available fuel. The success at Wylfa was a result of more than 12 years of work by Magnox Ltd, supported by Wood, to ensure end-of-life fuel cycle optimisation at four stations, which also included Sizewell, Dungeness and Oldbury.

We are now applying the lessons from this project with other reactor operators. Wood is also working with EDF Energy on an integrated fuel cycle management (IFCM) programme that minimises lifetime fuel costs for on-site fuel route operations.

## VVER reactor cleaning

Wood has developed innovative equipment and techniques for cleaning and visual observation of the interior of VVER reactors. Together with SIAL, our proprietary geopolymer encapsulation technique, we can offer a unique suite of cleaning and waste management services.

Slovenske Elektrarne operates a total of four VVER-440 V-213 reactors in Slovakia. Wood provided complex reactor cleaning, including pumping out the sludge from the reactor pressure vessel with concentrated boric acid. This had to be done immediately after fuel removal but before coolant was removed from the reactor. Reactor cleaning was carried out during outages, with a focus on decreasing the outage time. Wood's innovatively-designed equipment was used to pump sludge out of the reactor bottom.

# Providing software answers across the world

Wood's ANSWERS® Software Service provides nuclear codes which are used worldwide on a range of reactor types, including PWR, BWR, CANDU, VVER, RBMK, PBMR and experimental reactors. ANSWERS® products exist for nuclear criticality, reactor physics, radiation shielding, dosimetry and nuclear data applications.

For more than 30 years, these advanced analytical tools have enabled us to provide reactor operators with high-quality software and consultancy services.

Our global customer base helps us to stay at the forefront in nuclear code use and develop solutions that can be applied to all reactor systems. This learning is embedded in the software and applications we develop and implement with customers all around the world, across our full range of engineering services.

The ANSWERS® codes are constantly being developed and adapted for evolving nuclear technologies and have been used recently for work on advanced modular and small modular, light water, helium, liquid metal, molten salt, and fusion reactors.

## MONK

MONK provides advanced geometry modelling and detailed continuous energy collision treatment to create

## Nuclear Criticality Safety - MONK

MONK provides advanced geometry modelling and detailed continuous energy collision treatment to create realistic 3D models for an accurate Monte Carlo simulation of neutronic behaviour.

## Radiation Shielding and Dosimetry - MCBEND and RANKERN

MCBEND calculates neutron, gamma-ray and charged particle transport in sub-critical systems using Monte Carlo radiation transport algorithms, as well as the coupling between these different radiation types.

## Reactor Physics - WIMS and PANTHER

WIMS can model a wide range of reactor physics problems ranging from simple pin cell reactivity calculations to whole core estimates of power flux distributions for all thermal reactor types, including research reactors.

## PANTHER

The leading neutron diffusion and thermal hydraulics code for the analysis of any thermal reactor core.

## Nuclide Inventory - FISPIN

FISPIN calculates the changes occurring in the numbers of atoms of the nuclides of various species (heavy isotopes or actinides, fission products, and structural or activation materials) as a sample of nuclear fuel is subject to periods of irradiation and cooling.

## Analysis of pressurised water reactors (PWRs)

Historically, Belgium has used a WIMS/PANTHER route to analyse its PWRs as it performs well for UOX cores. The focus of this programme has been to develop and then validate new WIMS/PANTHER methods for modelling Belgian PWRs containing a mixture of UOX and MOX fuels.

Difficulties arise in this situation due to strong flux gradients between adjacent UOX and MOX fuel assemblies. Wood has been working collaboratively with Tractebel Engineering and EDF Energy over many years to develop a new route for analysing cores containing MOX fuel; and to validate new WIMS/PANTHER methods for modelling PWRs containing a mixture of UOX and MOX fuel.

ANSWERS® codes are constantly adapted to keep pace with evolving nuclear technologies



# Delivering Nuclear EPC

In South Africa, Wood has carried out numerous engineering, procurement and construction contracts to support operations for the South African public electricity utility, Eskom.

These projects have included providing emergency back-up diesel generators for both of the new Medupi and Kusile Power Stations and various projects at the utility's Koeberg nuclear power station, close to Cape Town, including the provision of additional spent fuel cooling capacity, station blackout mitigation, new hydrogen production and bulk storage plant, and replacement of part of the fire detection system.

**Our successful projects at Koeberg have included:**

- A replacement programme for the refuelling water storage tank, which had been affected by corrosion. Despite high winds, asbestos and radiological hazards, rope access, and working at height with heavy loads above safety critical equipment, Wood completed the dismantling of the tank room roofs, removing 12.6 tonnes of asbestos roof sheets and 14.1 tonnes of structural steelwork. Not only was this done ahead of schedule, there were no lost-time incidents on any of the 52 shifts worked and radiation dosage was limited to 246 microsieverts, less than a quarter of the recommended annual effective dose limit for a member of the public.

- Installation of reactor coolant pump seal emergency supply system as part of the station blackout modification project aimed at reducing the consequences of losing all onsite and offsite AC power. A new design was created to install an independent seal cooling system with an independent power supply system. The independent power supply system would also feed the existing onsite battery chargers via changeover switches. The design included a seal injection system, power supply design and installation and commissioning.

- A new design was required for the installation of an additional cooling loop in parallel with the existing spent fuel pool cooling system. With this, independent suction and discharge lines, an independent component cooling water supply and instrumentation and control systems were required. Wood worked closely with Westinghouse to manage the hardware installation, which was performed in three stages: simulator upgrade; phase A installation; and phase B installation, which included all the piping tie-ins, spent fuel pool/cask compartment penetration, and final cable terminations as well as flushing, hydro testing and test and commissioning of the systems.

Wood works closely with Westinghouse on projects to repair and replace vital systems at the Koeberg Nuclear Power Plant near Cape Town

# Technology and Innovation

Wood maintains 12,000m<sup>2</sup> of exceptional laboratory and test rig facilities in the UK and Slovakia which enable us to solve the world's most challenging nuclear problems.

They comprise radioactive handling facilities, gloveboxes, irradiation facilities and more than 50 individual laboratories and test rig halls. In the UK, we have the largest UKAS-accredited commercial radiochemistry laboratory.

**Our laboratory and bespoke engineering services contribute to operating reactor excellence across:**

- ageing management
- bespoke equipment design
- changing operational requirements
- modelling fidelity and lifetime management
- plant life extension

We provide our customers with insight into the likely performance of plant in the future and validation of the models used to underpin operation, maintenance and inspection strategies. We assess and develop materials to sustain operational performance both in the short term to permit timely maintenance and in the long term to support lifetime management strategies.

Our bespoke equipment is designed to meet changing operational needs and underpin the ability to operate safely with leading-edge inspection, engineering and testing capabilities (including NDT) delivered to plant locations that preclude standard maintenance and testing approaches. Our chemistry and corrosion capabilities support the management of plant, maximising lifetime and performance and minimising the risk of unplanned downtime.

This is complemented by our test rig facilities, which allow us to hone techniques to maximise accuracy and minimise disruption to generation. Our facilities are supported by approximately 700 experts who deliver a wide range of technical services across the full scope of the nuclear industry.

**Services include:**

- chemistry and corrosion
- criticality, shielding and human factors
- inspection and validation
- mechanical testing
- remote inspection and operations
- radiochemical and chemical analysis
- reactor physics and nuclear facility licensing/regulatory support
- radiological and environmental assessments
- structural integrity, materials and engineering simulation
- waste technology and management



Wood's people include international technical leaders in their fields



Wood is a global leader delivering technical, engineering and project services across the entire asset life cycle. We operate in more than 60 countries, employing about 60,000 people. We provide performance-driven solutions from development to decommissioning for a broad range of industries including all energy sectors, process and refining, power and utilities, mining and manufacturing.

For further information please go to:

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