ATOMS OF QUALITY

Alicia Dimas explores the role that quality plays in nuclear power generation and the consequences of quality deviations in the industry

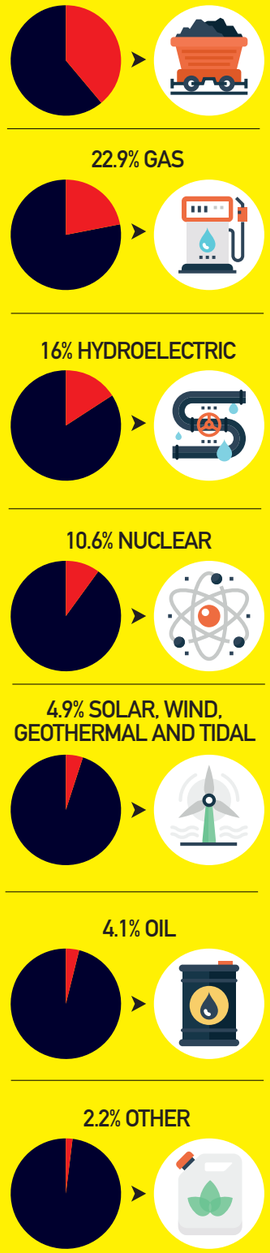
As countries come together to fight global warming, clean energy sources are increasingly coming under the spotlight. Unlike the United States, which recently increased efforts to develop the coal industry, many countries around the globe are increasing their investments in the clean energy production sector. For instance, the UK, which has recently achieved its first day without coal power since the Industrial Revolution, has pledged to phase out all coal-fired power by 2025 and plans for 14.5 GWe of new nuclear plants online by 2035.

Around the world, other sources of clean energy, such as those collected from renewable resources, are being used to reduce coal consumption. In 2017, for 300 consecutive days, Costa Rica's electricity was produced entirely from renewable energy, and in March 2018, Portugal generated more renewable energy than it needed for internal consumption (103.6%).

China is also investing in clean energy, with major projects for solar and wind farms, and 20 new nuclear power stations under construction. The country currently has 39 nuclear power reactors in operation, and its government's Energy Development Strategy Action Plan 2014-2020 is to increase to 58 GWe capacity by 2020, with 30 GWe more under construction.

Back in the UK, in addition to phasing out coal-fired generation until 2025, the UK government announced in 2015 that its new policy priorities ➤

WORLD ELECTRICITY ENERGY PRODUCTION BY SOURCE



for the country's energy plans include building new gas-fired plants, nuclear power plants and offshore windfarms to undo the country's reliance on coal.

Interestingly, a recent report by the Imperial College London, revealed that Britain's windfarms provided more electricity than the country's eight nuclear power stations during the first three months of 2018. Nonetheless, specialists are still adamant that nuclear power production is essential to successfully back away from highly polluting energy sources, like coal and petrol.

NUCLEAR IS THE WORLD'S SECOND LARGEST SOURCE OF LOW-CARBON POWER

Amanda McKay, Nuclear Quality Director at Balfour Beatty, and Chair for CQI's Nuclear Special Interest Group (NucSIG), agrees that nuclear energy production is crucial for the clean energy industry. She says that unfortunately renewable energies cannot provide baseload electricity that the UK requires. "Renewables will, I think, replace some of the elements of coal and gas. But nuclear is a carbon-neutral way of developing and delivering the baseload electricity the UK needs."

According to the World Nuclear Association, nuclear energy provides almost 11% of the world's electricity, from 450 power reactors. It is the world's second largest source of low-carbon power, after hydroelectric.

The UK has 15 nuclear power reactors which generate about 21% of the country's electricity, but almost half of these reactors will be retired by 2025. These reactors will have reached their 'finite life deadline', beyond which it is not economically feasible to operate them.

The World Nuclear Association states that early nuclear plants were designed for a life of about 30 years, though with refurbishment, some have proved capable of operating well beyond this. Newer plants are designed to operate for 40 to 60 years. At the end of the life of any power plant, it needs to be decommissioned, cleaned up and demolished so that the site is made available for other uses.

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From building to decommissioning, nuclear power facilities have to have safety and quality at their core, to avoid quality deviations and safety concerns. Recent problems with the building of Flamanville, a nuclear power facility in France, highlight just how crucial it is to ensure high quality standards. French state-owned EDF Energy, the nuclear electric power generation company building Flamanville, recently warned it could run further behind schedule and over budget. The announcement follows the detection of quality deviations on 150 welds in a system used to transport steam to turbines, used for electricity generation, for the €10.5bn (£9.2bn) plant.

Flamanville's reactor design is the same as the one being used at the delayed plant in Olkiluoto, Finland, and at the Hinkley Point in Somerset, UK, which developer EDF admits is also over budget, by at least £1.5bn, and 15 months behind schedule. Paul Murphy, CEng, CQP, BSc, Nuclear Safety Inspector at the Office for Nuclear Regulation (ONR) in the UK, explains that the French Nuclear Safety Regulator, Autorité de Sûreté Nucléaire (ASN), was informed by EDF, the operator of the Flamanville European Power Reactor (EPR), that welding flaws in pipework had been discovered during pre-startup checks. These flaws were not detected by post-manufacturing non-destructive testing (NDT). ASN carried out an investigation into the circumstances that may have contributed to the flaws not being detected, and to review the action plan set in place by the operator, following the detection of this anomaly.

"ONR has formal bilateral arrangements in place with ASN, so we were aware that EDF had detected quality deviations on the welding of the pipes of the main secondary system at Flamanville," Murphy reveals.

He adds that ASN identified a number of factors which contributed to the flaws not being detected at the manufacturing stage, including lack of adherence to NDT procedures and ineffective surveillance of the work being carried out. ASN considered that the arrangements for carrying out rechecks of the welds by the operator were appropriate. They have now asked the operator to check welds on other pipework circuits, which were made by the same manufacturer. "Learning from events at home and around the world is a key ONR expectation on the UK nuclear industry. International and national nuclear industry bodies and regulators share and act on feedback," Murphy says. "The lessons from the quality issues at Flamanville are being considered by ONR and the industry. ONR will ensure that timely and effective actions are taken by affected UK licensees to address any learning points."

In fact, the EPR projects at Flamanville and Olkiluoto have previously been affected by shortfalls in quality performance in design, manufacturing and construction. Hence, Murphy explains that, as the UK embarked ➤

on its own new nuclear reactor build projects, ONR recognised that more effort was required by UK operators, to ensure that the risks of similar shortfalls were controlled. The control of supply chain risks was identified by ONR as a key improvement, within the organisation's five-year strategic plan, in 2015.

"ONR encouraged UK licensees to consider their supply chain's risks and implement effective controls to mitigate these risks. Much work has been done under the auspices of industry improvement forums, such as the Safety Directors Forum and the CQI's Nuclear Special Interest Group (NucSIG). Last month, we issued the results from our first chief nuclear inspector's inspection, which focused on supply chain management at Hinkley Point C."

Murphy adds: "It is my belief that there has been a step change improvement in the licensees' understanding of their supply chain's risks, and the extent and effectiveness of the controls that licensees have applied to address [these] risks."

David Rasdell, Governance, Systems and Assurance Manager for Ansaldo Nuclear, thinks the expected delays in the construction of the nuclear power station in France were unavoidable, as the initial reports on the case suggest that there have been issues with a specific supplier's manufacturing plant.

It emerged that quality records have been falsified, and that this practice has been ongoing for some years. "Could this have been avoided with better quality control? I don't think so."

Rasdell explains that he believes EDF assessed its suppliers and their systems to ensure they meet the company's requirements and those of the relevant national and international standards applicable to the project. This procedure would have indicated that the right quality controls were in place. "I would expect that EDF would have visited the manufacturing process regularly for various witness hold points, as specified in approved quality control inspection and test plans."

He adds that the fact that the problem got so far without detection, demonstrates a strong culture of undermining the quality controls that should be there to check the integrity of the product in the first place.

So what role can quality play in avoiding such problems? Rasdell says a strong manufacturing assurance programme can go a long way to ensuring the product is fit for purpose and has the integrity built in all the way through the manufacturing process.

"Having a quality culture that instils the right attitudes of ensuring concerns can be raised without fear of repercussions is also an important thing to have," he adds.

PREVENTING QUALITY DEVIATIONS

In such a safety-sensitive industry, preventing quality deviations is not just a quality aim, but also a matter of national, and even international, security. Regulation is strict to ensure the safety of a nuclear plant is not compromised by a quality failure. This doesn't just apply directly to the constructor or operator of the plant, but extends to every pier of the supply chain.

"We are very keen on making sure that the supply chain delivers effectively, making sure that we haven't got counterfeits, fraudulent or suspect items in our supply chain," McKay says.

She highlights the importance of personnel training and induction programmes, as well as regular safety briefings. "Every week you will see a large number of toolbox talks and briefings given to every part of the workforce, covering new topics.

Covering not just the conventional health and safety, but nuclear safety, quality and environmental management, and trying to get across some key issues."

McKay talks about the importance of empowering people and having a clear leadership culture. "The workforce knows it's not acceptable to deliver second best," and as a result, McKay says her company gets many observations from the workforce, denouncing when things are incorrect. "They'll stop and make sure that something is corrected before they continue. It's about building a culture where deviation is unacceptable."

WORLD'S BIGGEST PRODUCERS OF NUCLEAR ENERGY

Source: World Nuclear Association (2017)

Having the right workforce and ensuring everyone understands the importance of following safety procedures, and the highest quality principles, seems to be the key to avoiding deviations in the nuclear sector.

After all, the strictest regulations will be of no use if people don't comply with them.

"I think that getting the right people and culture is a must," says Rasdell. "Having clearly defined roles and responsibilities, and robust project quality leadership is key to embedding a strong culture of quality and nuclear safety within the project or organisation. This has to be embedded from the top down and from the bottom up."

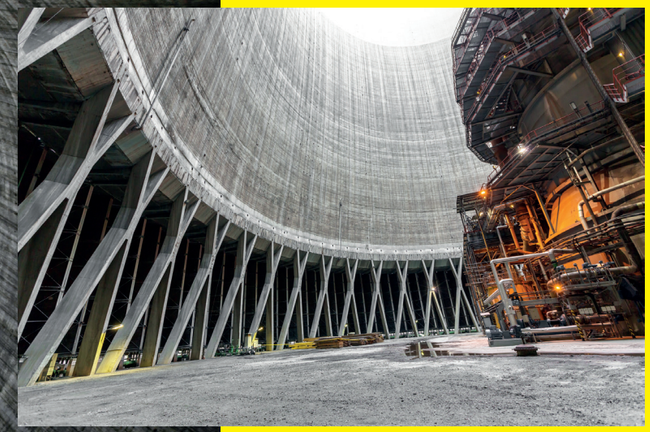
Rasdell adds that the key arrangements for managing quality need to be in place, such as quality planning, management of documentation, supply chain management, and control of materials and records.

Rasdell says Ansaldo Nuclear, which specialises in the design, manufacture, assembly, test, installation and commissioning of customised solutions for the decommissioning, defence, and new build nuclear markets, adopts different quality tools depending on the issue it is tackling. The company starts by employing qualified and experienced personnel and then puts them through a thorough quality induction programme. "We then have a dynamic and robust quality management system, which as you would expect, defines how we manage our business. For complex issues we have a 'Five-step problem-solving' process and for the completion of projects, a 'Learn from experience' process. Underpinning all of this, of course, is the organisation's culture."

"I THINK THAT GETTING THE RIGHT PEOPLE AND CULTURE IS A MUST"

Ansaldo Nuclear recognises the value of quality management to mitigate serious risks. Amongst many other quality procedures, it employs suitably qualified and experienced persons (SQEP), quality plans, manufacturing inspection and test plans, route cards and lifetime quality records. During the design and manufacturing stages, Design Failure Mode and Effect Analysis (DFMEA) and Process Failure Mode and Effects Analysis (PFMEA) are used to identify potential risks and failures and their mitigating actions defined. The company has developed compliance matrices all the way through from tendering to delivery with regular reviews and updates as required. Throughout the project, there are project audits and quality surveillance, both in-house and at suppliers. Nuclear safety presentations are held at project kick-off and prior to manufacture.

Besides all the actions taken by the organisation, Rasdell highlights that international standards, such as ISO, have an important role to play, as they can ➤



Regulation is strict to ensure the safety of a nuclear plant is not compromised by a quality failure

give a great basis on which to build, not only Ansaldo Nuclear's quality system and equipment specification and performance, but also its quality culture. "There is also the fact that they can set the 'bar' in terms of the minimum standards to be expected," he adds.

However, nuclear security goes beyond the safety and quality measures that each company in the sector adopts: it is a national and even international issue. The International Atomic Energy Agency (IAEA) plays an important role in regulating the industry globally.

In the UK, all nuclear site operators are required by law to hold a nuclear site licence issued by the ONR. Murphy, who works for the British organisation, tells *QW*: "From cradle to grave, the licensee must demonstrably reduce safety risks, so far as it is reasonably practicable. In furtherance of this, there are 36 conditions attached to each licence." These licence conditions provide a framework for the licensee to develop demonstrable modes of operation that ensure that high standards of nuclear safety are achieved, whilst providing the ONR with effective tools for exerting its regulatory control.

Licence Condition 17 requires licensees to make and implement adequate quality management arrangements for all matters which may affect safety. Murphy says the inclusion of this licence condition demonstrates that ONR believes the application of adequate quality arrangements is essential to achieving nuclear safety. The licensees are required to apply effective quality assurance to all safety related activities associated with the design, manufacture, procurement, construction, commissioning, operation and ultimate decommissioning of the installations.

Murphy stresses the role leadership plays in ensuring this safety culture and making sure it is compliant with effective processes that control risks, like those required by ISO 9001: 2015.

The operation of nuclear facilities presents uniquely high hazards which must be effectively controlled. Murphy says: "The nuclear industry has historically been at the forefront of developing and deploying quality tools and standards to bring about the necessary controls. Industry specific, national and international standards and codes were developed. The UK nuclear industry was central to the development of BS 5750 and its successor ISO 9000 series of standards." He adds: "During the heyday of nuclear construction, nuclear companies drove the adoption of quality tools and techniques into the sinews of the supplier companies. It is not surprising therefore that one may find the whole panoply of quality tools and standards being variously deployed throughout the industry: from quality control and quality assurance, through total quality management, to Lean, Six-Sigma, Kaizan, among others."

"NUCLEAR COMPANIES DROVE THE ADOPTION OF QUALITY TOOLS AND TECHNIQUES"

UK legislation requires risks to be reduced so far as it is reasonably practical. Therefore, licensees must identify the nuclear safety risks associated with any undertaking and justify that the controls to be applied ensure the risks are sufficiently reduced. There are processes for mitigating risks in areas such as design, procurement, manufacture, installation, commissioning, operation, maintenance, modification, and dismantling. Murphy says these processes must be effectively designed, deployed and improved. "The obvious framework for achieving this is through the deployment of an effective management system – hence the requirements of Licence Condition 17."

Although ONR does not stipulate what quality standards a licensee or supplier should adopt, ONR's expectations are set out in guidance documents that anyone can consult on the organisation's website. For instance, ONR recommends the adoption of the following standards to set out relevant good practice:

- IAEA Standards and Guides: The International Atomic Energy Agency (IAEA) publishes safety standards and guides with a view to protecting people and the environment from the harmful effects of ionising radiation. The IAEA safety standards reflect an international consensus on what constitutes a high level of safety. A particularly relevant standard is IAEA GS-R-2 'Leadership and management for safety'.
- ISO management system standards, in particular, ISO 9001: 2015. In the UK, licensees generally hold certification to ISO 9001 for their management systems.

Regulations are not just written documents for the nuclear industry – they are part of its daily routine and are embedded in a project since the beginning. McKay says the regulator gets involved in a nuclear plant project before construction starts, to ensure all the safety procedures are met. "The regulator takes an active interest, not just in the licenced companies who build and operate these plants, but in the supply chain as well."

She adds: "You've not only got your customer auditing and monitoring you, you've also got the regulator as well. That's something fairly new but it works very well. Regulators are very interested in maintaining that safety culture throughout a project, and that's what they are looking for."

WHAT THE FUTURE HOLDS

The nuclear industry already has an eye on the new ISO 19443 'Quality management systems – Specific requirements for the application of ISO 9001:2015 by organisations in the supply chain of the nuclear energy sector supplying products and services important to nuclear safety'. The standard is still being prepared, but McKay says it will be the nuclear sector's ISO 9001. "ISO 19443 is a brand-new standard, which is just in draft at the moment, but it will be the ISO 9001 for the nuclear sector. Very similar to how the aerospace and automotive industries have a version of ISO 9001 which is specific to them."

She adds: "The nuclear industry is creating that itself. We are already looking at elements of ISO 19443 regarding how we operate and how our supply chain operates. So, while it's not a public standard yet, we believe it will help us in the way that we operate."

But other changes are coming to the energy market that will affect the nuclear industry even deeper than a new standard.

Murphy tells *QW*: "It is my opinion that, in the near and medium-term, nuclear energy produced by fission processes remains the most practical, viable alternative to replace fossil fuel, in order to achieve the necessary reductions in greenhouse gas emissions." He says this is already recognised by many governments, academics and environmentalists worldwide and there will be a significant increase in nuclear power generation in the future.

Murphy adds: "I am a huge fan of solar power and believe that it has great potential, but nuclear must form a significant part of the energy mix for some time to come. The development of small modular nuclear stations is being pursued internationally. Such designs will benefit from simplicity of design, build and operation and will likely be used to provide power to remote locations and specific energy intensive industries. I wonder if Bitcoin miners have considered small modular reactors to meet their huge electricity consumptions and bills?"

Rasdell also considers nuclear energy to have a crucial role in cutting down greenhouse gas emissions. "I believe that both renewables and nuclear are on an equal footing, in terms of output in the UK at the moment." As the coal-powered energy stations in the UK are coming to the end of their working lives, Rasdell believes the country has the opportunity to build further low-carbon or zero-carbon electricity generation facilities.

Rasdell adds: "It makes sense to me that an integrated policy on generation is the way forward, ensuring that there are always several options to ensure there is enough power generated to feed demand. Nuclear has a part to play in that approach, provided that we can ensure we give the confidence and evidence that quality is built in through the entire project lifecycle, and is not compromised. We have seen some recent examples where that has not been the case, and the results are not good reading." ■

NUCLEAR ENERGY TIMELINE

1789: Uranium was discovered by Martin Klaproth

1895: X-rays and ionising radiation were discovered by Wilhelm Rontgen

1898: Pierre and Marie Curie isolated polonium and radium from the pitchblende and coin the term 'radioactive'

1932: James Chadwick discovered the neutron

1938: Otto Hahn and Fritz Strassmann split uranium atoms with neutrons

1939: Francis Perrin introduced the concept of the critical mass of uranium

1954: Obninsk reactor in the Soviet Union becomes the first commercial nuclear power plant

1974: The French prime minister, Pierre Messmer, launches nuclear power programme

1979: Three Mile Island reactor suffers a partial meltdown. Radiation mainly contained

1986: Chernobyl reactor suffers a large power excursion resulting in the release of large amounts of radiation

2011: Tsunami causes Fukushima reactors to lose backup generators, suffer core meltdowns and hydrogen explosions

Source: World Nuclear Association and HuffPost