The Foundation for Science and Technology
Discussion Event Record Note

New Nuclear and the UK Energy Strategy

Date and Location: 15th June 2022 at The Royal Society

Chair: The Rt Hon. the Lord Willetts FRS
Chair, The Foundation for Science and Technology

Speakers: Julia Pyke
Sizewell C Director of Financing and Economic Regulation, EDF
Sophie Macfarlane-Smith
Head of Customer Engagement, Rolls Royce SMR Ltd
John Corderoy
GDF Technical Programme Director, Nuclear Waste Services
Professor Paul Monks
Chief Scientific Adviser, Department for Business, Energy and Industrial Strategy

Report Author: Gavin Costigan
Chief Executive, The Foundation for Science and Technology

Audio/Video Files: www.foundation.org.uk

Hash tag: #fstnuclear . Twitter Handle: @FoundSciTech .

JULIA PYKE began by noting the success of the Hinkley Point C reactor construction, which was given leave to build in 2016. The majority of the future energy system will be produced by renewables and will be predominantly intermittent. Hinkley could be physically flexible, but the contract for difference makes it economically inflexible. It will get paid a certain rate to put electricity onto the national grid, but not if it diverts some of that electricity, for example, for hydrogen electrolysis, even if that was what the overall system needed. Sizewell C has been designed to be economically flexible, as well as physically flexible, being paid to be available rather than to put power into the grid.

As well as being used for hydrogen electrolysis, nuclear produces heat, and in other countries the systems have been successfully designed to allow that heat to be used for other purposes. In Sizewell, there will be valves to take out steam. Around about 400 megawatt thermal can be taken without significantly impacting electrical output. This represents low cost, low carbon heating – which could provide a useful service. One example might be heat assisted electrolysis for hydrogen. Another is heat powered desalination, which would be of great value to agriculture. And thirdly, with partners and funding from BEIS, Sizewell is developing a prototype for heat powered direct air capture.

Sizewell expects to get an indicative investment grade rating for the debt, which means they will be able to raise the £20 billion of debt that they need. It is the first time a nuclear facility has been funded in this way in the UK. The multi-purpose nature (beyond grid electricity) should make it event more attractive to the investment community.

Sizewell will be learning from Hinkley. With the exception of the marine works (which vary with geographic location), Sizewell will be a direct replica of Hinkley. There will be no changes in the design allowed. And they will use the Hinkley Point supply chain, so lessons from Hinkley don't need to be relearned. 90% of the Sizewell supply chain will be UK based.

Julia noted that the investment in Sizewell will provide energy security, electricity which is not weather dependent, and a machine that can maximise the output of heat (perhaps 400

MW thermal). The strike price for Hinkley will be £92.50/MWh, of which £11- £13 is construction and £20 operation, fuel and decommissioning. The rest represents interest and cost of capital, given the long development and construction and that all the risks are taken by the company. In Sizewell, costs will be cheaper by using the same design and supply chain, but also because the cost of the money is less in a regulated asset-based model. An electricity system which is primarily renewables but with the right amount of nuclear is a cheaper system, and household bills will go down when Sizewell comes on line.

SOPHIE MACFARLANE-SMITH began by introducing Rolls Royce SMR, a company with Rolls Royce as the majority, but not the only, shareholder. Rolls-Royce have several decades experience making nuclear reactors for submarines, and are developing the technology for Small Modular Reactors (SMRs).

Nuclear power can develop large quantities of low carbon power very efficiently. The question is, how do we get more of it as quickly and as affordably as possible? Rolls Royce is looking to use the proven technology of pressurised water reactors, but delivering it as a standardised manufactured product, turning it into a commodity instead of a one off infrastructure project. The way they intend to do this is to deliver the complete power station (not just the nuclear island) in 1600 modules. Each module can be manufactured at a remote factory, transported by road and assembled on site.

These SMRs would not only be producing electricity for the grid, but also (for example) used to make synthetic aviation fuel and hydrogen and to provide district heating. There are many customers for this beyond the national grid, industries that need to decarbonise and are in need of electricity and heat. Several industries have concluded that they cannot decarbonise their sector with only wind and solar, they will need nuclear. SMRs are smaller in size and can be placed in areas where large nuclear can't go at the moment.

In terms of risks, licensing, manufacturing and assembly are not seen as significant risks, as SMRs are using established technology and construction, and neither is finance, with £2 billion being investable on the standard open market. The big challenge is sites. Prospective industrial customers want SMRs near their own facilities. More sites are needed, as is faster site permitting. The economics of this approach break down if site-specific licensing takes multiple years.

The final challenge for Rolls Royce SMR is scale. The demand is high for near term deployment, not just in the UK, and Rolls Royce is looking at how fast they can scale up their manufacturing facilities to deliver the demand.

JOHN CORDEROY introduced the Geological Disposal Facility (GDF) project. It was first recommended in the Flowers Commission report in 1976. The UK has been producing radioactive waste since the 1940s, and because the UK has had many types of nuclear facility, it has a problem of both scale and complexity. Storing the waste as we do now is not an immediate problem, but we cannot expect future generations to keep paying to store waste produced many years ago, hence the need for more permanent disposal.

The existing policy for disposal was launched in 2018. As the waste stays active for thousands (and in some cases, hundreds of thousands) of years, the plan is geological disposal in a facility about 1000 metres below the sea bed that at full size might be 6km by 6km. There would be engineered vaults below the surface and a small surface facility of about 1 square kilometre. After a long period of operation (over 100 years), the facility would be sealed up.

Previous attempts at this in the UK have been unsuccessful, and the last one (2008-2013) was too rigid from a community perspective. The current plans are much more flexible. Other countries are ahead of the UK in this, including Finland, Sweden, and France. Switzerland and Canada are in their site selection process.

The aspiration for 24 gigawatts of nuclear by 2050 announced recently can be pretty easily accommodated, with the geological footprint increasing from perhaps five by five kilometres to about six by six. The GDF is very modular – like a mine, you build the first part that you need and then it evolves over the next 100 years.

There are four communities in the process, three are communities which already have nuclear power, and there is one that doesn't. For all four, there are seismic studies and feasibility work going on, with a decision in 2025 or 2026 to pick the two front runners, when more in-depth analysis will be done. Part of the "sell" to communities is that it's part of the green future – cleaning up the UK's environment.

Global experience is that whenever a government tries to force such a facility on a community, it doesn't work. So communities are at the heart of the process this time, to get them invested in an enterprise that they're going to be proud to host and be part of for a very long time.

PROFESSOR PAUL MONKS started by reminding the audience of the size of the problem to decarbonise the economy, and all the different contributions to that. He emphasized that what was needed was low carbon energy, not just low carbon electricity. He illustrated this with a graph showing UK usage of electricity, liquid fuel and gas. Gas is used to balance the electricity load, which reached 5TWh in a single day during the "Beast from the East" storm in 2018. As we move away from gas, we need to be able to balance demand in a low carbon way.

Currently, 17% of our energy consumption is electricity, with 43% in heating and 40% in transport. As we think of nuclear, we need to think about the rest of the future energy system. In that system, how do we ensure we can meet occasional peak demands? We are going to electrify a lot of the energy spent on transport and heating, and we will do it whilst moving away from gas.

The Energy Security Strategy builds on work from BEIS in 2020 and 2021, but with uplifted levels of ambition, partly in response to the energy issues arising from the conflict in Ukraine. Within the strategy, the ambition for nuclear was raised to 24GW by 2050, 25% of the UK's energy needs, with more site permits and changes to the operating model. Great British Nuclear is being set up as a new body to deliver this.

The strategy has many other ambitions to drive more rapid decarbonisation of our energy system and meet the demands of changing energy usage. We need different financial models, different ways to operate, and whole systems approach. BEIS will publish a strategic network plan later this year.

Beyond the Sizewell and the SMRs, the UK needs to look forward to the next generation of Advanced Modular Reactors, that are really designed to take forward cogeneration, and fusion. We know that we have the skills and supply chains for AMRs and cogeneration, and in particular as we decarbonise we need to ensure the heat from nuclear is not waste but a commodity. We will create a system where renewables create the base load and nuclear will balance that load. The nuclear energy can be used for hydrogen production, direct air capture, seawater desalination, and making ammonia, as well as direct use of the heat.

Professor Monks showed a diagram about current and future R&D programmes that will be needed and the technologies that will be needed. One of the key challenges to delivering this, and delivering new nuclear, is having the skilled people that we need. We have lost some of these skills and we need to make sure that we replace them.

When it comes to the cost of nuclear energy, we think about it in the wrong way. We need to think about the system cost of electricity, not the generation costs. Nuclear is more expensive to generate but can deliver at times that renewables can't. We need to optimise the systems cost. The UK spends several billion pounds each year on load balancing. Nuclear offers a trade off between capacity and generation.

IN THE DISCUSSION, the panel were asked how realistic it was that communities would accept SMRs and nuclear more generally. In response, the panel noted that demand from industry was growing for low-carbon power, and industry will come to where that power is. Communities are interested in the jobs that come with that. It was also noted that a currently non-nuclear community was interested in hosting the Geological Disposal Facility. There is a majority of the population in favour of nuclear. Many younger people are joining the nuclear industry as they see it as a green technology.

The panel were also asked about the technical staff needed for SMRs, in comparison to large nuclear sites. In response they noted that the number of staff needed was broadly proportional to size. The key issue was that with an expanding nuclear industry, there was a significant training requirement, but there was time to do that. The Green Task Force is thinking about the jobs needed for the Net Zero transition, including nuclear. One element which may help with skills shortages is to promote co-operation rather than competition across the nuclear industry. But skills could well be an issue, and we need to increase our ambition in delivering certain key high-end skills – not just in nuclear engineering but also in high-end construction.

The panel discussed the reliability of EPR reactors around the world, and pointed to success in several countries. They were asked about whether a closed fuel cycle would be better than an open one, and noted that a lot of material designated as waste for eventual disposal at the GDF was not earmarked to go there until at least 2080, with therefore plenty of time for reuse of technologies and priorities change. But in the near term, the priority was to use technology which already existed and was known to work well. There are also many things that the nuclear industry can learn from other sectors, particularly shipbuilding and defence. The panel also noted the potential opportunities internationally in being a leader in nuclear decommissioning.

Following a question on nuclear fusion, the panel noted that this was an area with real UK strength, a "UK moon-shot". And there was plenty to technology which would transfer over from an SMR to a small fusion reactor. On the possibility of an SMR in Anglesey, the panel noted that manufacture of the modules would take place elsewhere, so whilst there would be skills needed at any one site for assembly and operation, they would not be needed for manufacture.

The panel were also asked about whether climate change was being assessed within the design of nuclear power stations and the GDF, and it was confirmed that for the GDF, this had been a key part of the design, including the potential for rising sea levels. The GDF itself would also be based on low carbon construction. One single GDF would be sufficient for the UK's needs for well over 100 years.

Finally the panel were asked about making nuclear a better proposition for the investor community, who had seen previous nuclear projects significantly over budget and schedule. The panel noted that the Government had just announced that it was minded, subject to consultation, to give a regulated asset-based licence to Sizewell. The project will have investment grade debt, and thus the risk characteristics attributable to investment grade debt. In terms of the equity, the model produced is a capped upside and a capped downside. It should produce an extremely predictable long term return.

Gavin Costigan