

## **The role of Small Nuclear in UK Energy Security the Future of SMRs.**

### **1. INTRODUCTION**

Since privatization of the energy industry in the nineties, the assumption underlying UK Energy policy has been the unstated one that cheap gas would always be available. Since the early 2000s the increasing so-called Climate emergency has driven policy and behaviours towards renewable sources of energy. The assumptions of the policy on gas, even before the CO2 issue became key, was faulty from the outset. The reliance on last mile gas stations, the Peaking Stations, which are only activated at points of peak demand, meant that at a time when the gas market was limited by supply, prices would rise very dramatically. The assumption of an, in effect, infinitely elastic market in gas due to range of suppliers and the plentiful nature of the resource blinded policy makers to the risks.

These risks materialized dramatically in the light of the Russian aggression in Ukraine. This was specifically illustrated in Germany, where the green movement succeeded in closing the nuclear generating capacity thereby sealing reliance on Russian gas. The results of that on the German economy are now becoming evident.

Faced with the demand to de-carbonise and the unpredictable geopolitical impact of “events” (to quote the late Prime Minister Harold Macmillan) on the supply of fossil fuels, the challenge for governments is how to provide appropriately priced, reliable energy, specifically electricity, in a time when electricity demand is rising at a very rapid rate, increased by the demand to power data centres and the shift in transport. This baseline, reliable, “always on”, climate independent source is recognised as being nuclear, and small nuclear, the Small Modular Reactors (SMRs) are increasingly touted as a preferred option.

What is an SMR? An SMR is a small nuclear fission reactor, which uses the same science as our existing reactors, and which are very similar to the power plants that have been running our submarine fleet for nearly 70 years without an accident. They will generate around 300MW of power each, enough to power Coventry or Glasgow. Four such units could power the West Midlands. They will run for 60-80 years and will produce that power 24/7 except for planned down time. Four such units would occupy several football

itches plus surrounding infrastructure, they are about 1/10<sup>th</sup> the size of a conventional nuclear power station.

Each installation would provide some 100-200 jobs plus the knock-on, or multiplier economic effect in local communities. They are around three – six stories in height, or around 30m.

## 2. SOURCES OF ELECTRICITY SUPPLY

Whilst the achievement of the UK in implementing renewable sources of power are to be welcomed, the reality of our supply situation is a little different from the media depictions of it. The following snapshots of supply demonstrate this.

**NB** These figures were taken at random on the date and at the times indicated. The source of the Electricity is shown in the column on the left. The source of imports is shown. “Renewables” is the sum of Wind, Solar, Hydro and Biomass.

Date	12/02/2025	13/02/2025	14/02/2025	16/02/2025	17/02/2025
Time	14.47	13.30	09.10	14.09	11.54
Source					
Of Power	GW 47.4	GW44.4	GW46.2	GW44.5	GW44.2
Gas	49.3%	54.6%	49.2%	21.5%	38.3%
Wind	18.5%	12.5%	23.1%	31.4%	24%
Nuclear	9.6%	9.7%	9.3%	11.0%	9.7%
Biomass	6.6%	6.9%	6.6%	8.1%	7.1%
France	6.1%	7.1%	0	10.2%	1.6%
Denmark	3.2%	0.0%	0	2.3%	1.9%
Norway	3.1%	3.1%	0	3.6%	2.2%
Solar	1.5%	3.3%	2.4%	5.1%	11.1%
Hydro	1.1%	0.9%	0.9%	0.4%	0.3%
Storage	0.6	0.0%	0.1%	0.0%	0.0
Other	0.6	0.8%	0.9%	1.2%	1.1%
Belgium	0	0.0%	0	2.2%	0.0%
Coal	0	0.0%	0	0.0%	0.0%
Ireland	0	0.3%	0.0	0.0%	0.0%
Holland	0	0.0%	0	2.7%	2.4%
N Ireland	0	0.9%	0	0.0%	0.0%
Oil	0	0.0%	0	0.0%	0.0%
<b>Renewables</b>	<b>27.7%</b>	<b>23.6%</b>	<b>33%</b>	<b>45%</b>	<b>42.5%</b>

Source GB Grid Carbon Intensity, Data from the ELEXON Portal

Whilst renewables, especially wind are making a healthy contribution to our electricity generating capacity the table above shows that over the six days it has still required between c76.4% and 56.4% to be provided from nuclear and fossil fuel plus imports which have provided around 10%. The challenge

to replace the more or less 20%-50% of gas-powered generation is therefore a challenge.

### 3. CURRENT COSTS OF POWER

Determining the cost per kilowatt-hour (kWh) of electricity in the UK for various energy sources involves analysing the levelized cost of electricity (LCOE), which accounts for the total lifetime costs of building and operating a power plant, divided by the total electricity generated over its lifetime. As of 2024, the LCOE for different energy sources in the UK is given below.

**3.1 Gas-fired power stations:** The LCOE for gas-fired power stations has been influenced by fluctuating gas prices. Department for Energy Security and Net Zero (DESNZ) In a 2023 report, DESNZ estimated the LCOE for Combined Cycle Gas Turbine (CCGT) plants to be approximately £114 per megawatt-hour (MWh) for 2025, using 2021 as the price base.

Note Peaking plants can be many times more expensive than this. One example in Lancashire recently ran for 20 hours and was paid £2,900 per MWh.

The LCOE for gas-fired power is highly sensitive to natural gas prices. The Office for Budget Responsibility noted that increases in gas prices have made renewable energy sources more competitive, as the cost of gas-fired generation has risen significantly.

**3.2 Solar power:** Solar energy contributed 5% to the UK's electricity supply in 2024. The LCOE for solar power has been decreasing over the years due to technological advancements and economies of scale. In 2024 the average LCOE was £62.50 per MWh with a range between c£28-£110. It may be expected that this will fall further. However, there are some issues in the provision of solar. The principal source of solar panels is China. The environmental impact of mining the materials needed is not clear. However rare earth minerals are not rare in the sense they're not to be found, they are rare in the sense that their concentration in most places is very low. Accordingly, very large volumes of material need to be processed for each tonne of pure material. It is estimated that the cost in 2024 prices may range between \$10,000 and \$50,000 per tonne of raw material, before any manufacturing costs. When the human issues of mining and exploitation are taken into account it is clear that the overall lifetime costs of renewables for solar from mine to disposal are high (as they are for battery manufacture, but that is a different topic). Additionally at present there is no industrial scale process or market for recycling solar panels.

**3.2 Onshore wind:** Onshore wind projects have seen significant cost reductions. In the 2022 Contracts for Difference (CfD) auction, onshore wind projects secured contracts at an average strike price of approximately £50.90 per MWh in 2024 prices.

**3.3 Offshore wind:** Offshore wind has experienced substantial cost declines. In the 2022 CfD auction, offshore wind projects achieved strike prices as low as £37.35 per MWh (2012 prices), translating to approximately £58.87 per MWh in 2024 prices.

**3.4 Big Nuclear power:** Nuclear energy's costs are influenced by high capital expenditures and long construction timelines. The Hinkley Point C nuclear plant has a strike price of £92.50 per MWh (2012 prices), equating to about £130 per MWh in 2024 prices.

**3.5 Small Nuclear** Estimates vary and of course are estimates. The range of figures provided by Rolls Royce (£55 at 2021 prices) and one of the development teams working to fund and build these ( £78 per MWh to £100) are wide given that there are none in operation, although the latter figure is pitched deliberately high to provide an indicative IRR to potential investors.

The challenge of renewables is that of continuity. Whilst Wind and solar contribute increasing generating capability, it is obvious that both are climate dependant. Nuclear is not. The replacement of the combined % of Gas and imports implies that some 40% of power needs to come from other sources of which base load 24/7 reliability is an important element of energy policy, but one which is often overlooked. The challenges of small nuclear of course include treatment of waste and safety measures. I have not addressed waste disposal or environmental impact. But the issues here are small compared with microplastics, persistence of mercury, hormones in drinking water and many other. Like these, nuclear wastes need proper treatment, but that is outside the scope of this paper.

### **3.6 Overall Average cost of power in 2024**

An industry average LCOE from all generating sources would be a useful benchmark but one which is difficult to calculate and very debatable since the figure will fluctuate based on market conditions and demand.

However, Calculating the weighted average Levelized Cost of Electricity (LCOE) for the UK's energy generation involves combining the LCOEs of various energy sources, weighted by their respective shares in the electricity

mix. Based on data from 2024, the UK's electricity generation mix was approximately:

- Wind: 30%
- Gas: 26%
- Nuclear: 14%
- Biomass: 7%
- Solar: 5%
- Imports: 14%
- Hydro and Storage: 3%
- Coal: 0.6%

NB Coal stopped being a source of power in 2024.

The Department for Energy Security and Net Zero (DESNZ) provides central LCOE estimates for projects commissioning in 2025:

- Onshore Wind: £38 per megawatt-hour (MWh)
- Offshore Wind: £44/MWh
- Large-scale Solar Photovoltaic (PV): £41/MWh
- New Nuclear: £109/MWh
- Gas (Combined Cycle Gas Turbine - CCGT): £85/MWh
- Biomass: £95/MWh
- Hydro: £90/MWh

Assuming the wind energy contribution is evenly split between onshore and offshore (15% each) and considering imports as having an average LCOE of £70/MWh, the weighted average LCOE can be estimated using the percentages above to weight the average annual cost of each source in a formula to estimate the average LCOE for power in the UK in 2024. This calculation yields an estimated weighted average LCOE of approximately.

**£75.50 per MWh for the UK's electricity generation mix in 2024.**

It is important to note that actual costs can vary based on specific project conditions, technological advancements, and market dynamics.

This figure is remarkably close to the estimated cost of small nuclear.

I have ignored the subsidy to wind and solar and the costs of turning off turbines at low demand levels, since as demand increases it is to be supposed that turbines will be turned off less often. This may be an optimistic

assumption given the difficulty of matching demand to supply in the renewables sector.

#### **4. IMPLEMENTATION AND RISK**

The case for SMR is based on the relative ease of construction, the smaller footprint needed, the relative speed of implementation (compared with Hinckley Point or Sizewell) and the economic benefits. However, even though the majority of current SMR designs are based in well tried and indeed quite old technology, there are a number of stages that must be satisfied before a plant can be built. These all contribute to delaying the construction phase of an SMR which, estimated at about three years, is hugely less than the current mega scale Power Stations.

##### **1. Technology Design Approval**

The initial process for technology approval in the UK is the Generic Design Assessment which is a voluntary process to assess the environmental and safety aspects of a technology. The GDA is conducted by the Office for Nuclear Regulation (ONR), the Environment Agency, and Natural Resources Wales to evaluate the safety, security, and environmental implications of a proposed nuclear reactor design before any site-specific applications are made. The GDA process typically spans approximately 48 months. At present both the Rolls Royce SMR and the Westinghouse SMR are going through this process, with RR probably ahead in the process. In common with other elements of permitting for the small modular reactors, this process is being looked at to see whether the smaller and more easily constructed SMRs need to go through the whole process in the same way and to the same extent as do the large-scale reactors.

- 2. Nuclear Site Licensing:** Any organization intending to construct and operate a nuclear facility must obtain a nuclear site licence from the ONR. This licence ensures that the operator understands the associated hazards and has the organizational capability to manage safety effectively. The licence encompasses 36 standard conditions covering various aspects, including design, construction, operation, and decommissioning. In the case of SMRs which are effectively a new use of nuclear technology, Regulatory Justification is also needed, and the proposed development must undergo a justification process to assess whether its societal and economic benefits outweigh the potential

health detriments from ionizing radiation. This assessment is conducted under the Justification of Practices Involving Ionising Radiation Regulations 2004.

3. Environmental Permitting and the DCO: Operators are required to secure environmental permits from the relevant environmental agencies such as the Environment Agency in England, the Scottish Environment Protection Agency (SEPA), or Natural Resources Wales (NRW) for activities that might impact the environment. These permits cover areas like radioactive discharges, cooling water discharges, and the operation of standby generators. Permitting is undertaken in tandem with the application for a Development Consent Order (DCO) necessary for nationally significant infrastructure projects, including nuclear power stations. This is a special type of planning application assessed by the Planning Inspectorate, which then makes a recommendation to the Secretary of State who makes the final decision. The time needed for the grant of a DCO is also prolonged typically several years.

4. Construction and operation.

The major difference between SMR construction and mega plants is that much of the plant is factory made to be assembled on site. The key components of Pressure vessel, pipework, turbine, and generator are all standard components and whilst the casting of the pressure vessel does need specialist facilities it too is delivered to site to be assembled into the plant. This reduces construction risk which is mainly around the integration of the reactor on the “nuclear island” to both Generator and Turbine.

Once in operation the plant runs continuously for 60-80 years except for refuelling and standard planned maintenance.

All this said the arguments in favour of a new fleet of small reactors is a strong one.

At present there are at least 8 communities known to us who positively want a SMR on their doorstep, on the grounds of jobs, economic benefit, and regeneration. When four can be fitted on a football field the impact on neighbourhoods is limited and even the issue of recycling fuel is less challenging using small amounts of pelleted fuel.

To enable this to happen, however, requires that policy makers and regulators revise their approaches and processes without lessening the standards and safeguards they apply.

Assume that between 25% and 40% of existing generation capacity is needed to be moved from Gas to nuclear (which in turn assumes that 60%-75% is met primarily through renewable with no imports). This implies roughly a doubling of renewables, mainly wind. It also would require about 15GW-20GW of nuclear; 4GW from existing and new major plants and 10 – 14 SMR plants of 4 units each. The investment required would therefore be of the order of £20-£28bn, less than has been spent on HS2 and twice the cost of the Elizabeth Line. How is this to be financed at a time when Government apparently neither has the money nor the means to acquire it?

## **6. FINANCING NEW NUCLEAR.**

There is a common belief that nuclear must be funded by government. This is certainly the view expressed by Civil Servants in DEZNEZ and is also the belief of the two suppliers that we are close to. Partly this view stems from the reluctance to accept any balance sheet risk on the part of the technology providers, who view their role as being purely a supplier. Partly the view stems from the lamentable track record not only in the UK of building the most recent mega scale reactors which are hugely over time and budget- but then so is HS2.

General Industry assessment is that the likely cost of the first round of SMRs are of the order of £2bn per unit, which may decrease for volume (i.e. >4 units) subsequently. Whilst this is a significant sum of money, it is nowhere near the cost of HS2 (original budget £37.5, currently £27bn and 14 years, final estimate c£80bn), The Elizabeth Line (£18.8bn vs £14.4bn and 13 years), or the Thames Tideway which compared with the other examples has performed well with an original estimate of £4.2bn and a current estimated cost to complete of c£5bn.

Seen in the context of these projects, £2bn for generating c330Mw of power over 60-80 years appears a snip!

However, the price is still high and although Government has hopes of attracting private sector investment it has no effective way to ensure this, and the current mechanism of providing developers with a return via the mechanisms of a Regulated Asset Base or a Contract for Difference do not provide a return until the plant is operational. Guarantees are seen as, in effect, government underwriting the whole programme, and therefore delaying but not avoiding the risk of the public sector having to fund the full cost. There are other options however.

If the mission to build an SMR is viewed as a start-up, then the funding challenge is simpler. Why? Because the stages of the project can be used to develop a risk profile that gives any investor an exit at a given point should the project run into difficulties. Clearly there will still be losses but smaller ones. Any venture capitalist is accustomed to this scenario which is why such very large returns are demanded as a compensation for the projects which do not work. What is the risk profile of the first-of-a-kind SMR?

There is a fairly high-risk initial phase spanning perhaps five years:

- *Is the technology approved?* This risk falls on the supplier- no governmental cost but cost to the product development company a normal business cost. Some preparatory costs by the developer will however be needed.
- *Is the site approved?* There is cost here for the developer, and this has been estimated at £5m-£25m dependent on the site – and if remediation is needed of a contaminated site these costs can be much greater. But without an indication of the social and geographical suitability of the site and its seismic characteristics no remediation would be undertaken. It should be pointed out that the site still has development value even if permission for an SMR is not granted, thereby mitigating the loss for a developer.
- *Is the development approved?* This is a costly exercise because it involves the granting of a DCO which itself can be subject to Judicial Review in some cases, increasing cost and especially time.

In total the estimate to get to a shovel ready project can range from £150m-£350m for the first five years of an overall programme of c10 years of which consenting and permits takes up at least five and the construction 2 years plus 100% contingency.

Once at shovel ready the project is not impossible to finance, and a number of institutions have indicated their readiness to be involved. The key for investors is the reduction of risk in the first five years.

Government can provide a number of facilitating measure to attract venture or risk capital and to make early-stage programmes investable.

1. Simplify and speed up the processes of technology and site approval, undertaking these in parallel and to well understood and publicised processes.

2. Limit the scope for legal challenge once a decision in principle has been made.
3. Allow an insurance syndication of early-stage risk by engaging with the insurance market to develop existing products into specific offerings for these initiatives.
4. Offer some funding for the first of a kind in the first five years of development providing the results of the programme are provided as open source to all market entrants. There is precedent here for “precompetitive” funding of new concepts.

## **7. CONCLUSION.**

In a situation where at any one point between 30% and 70% of our power is still from fossil fuels or imports, with 5 years to go to net zero or, as I prefer to say, *climate independent sources*, it is not possible to see how we can do without small nuclear, and if we begin now, the first plants would come on line in 2033-2035. Even if all power is generated from renewable sources, the issue of intermittency remains and is to date insurmountable.

We cannot wait.