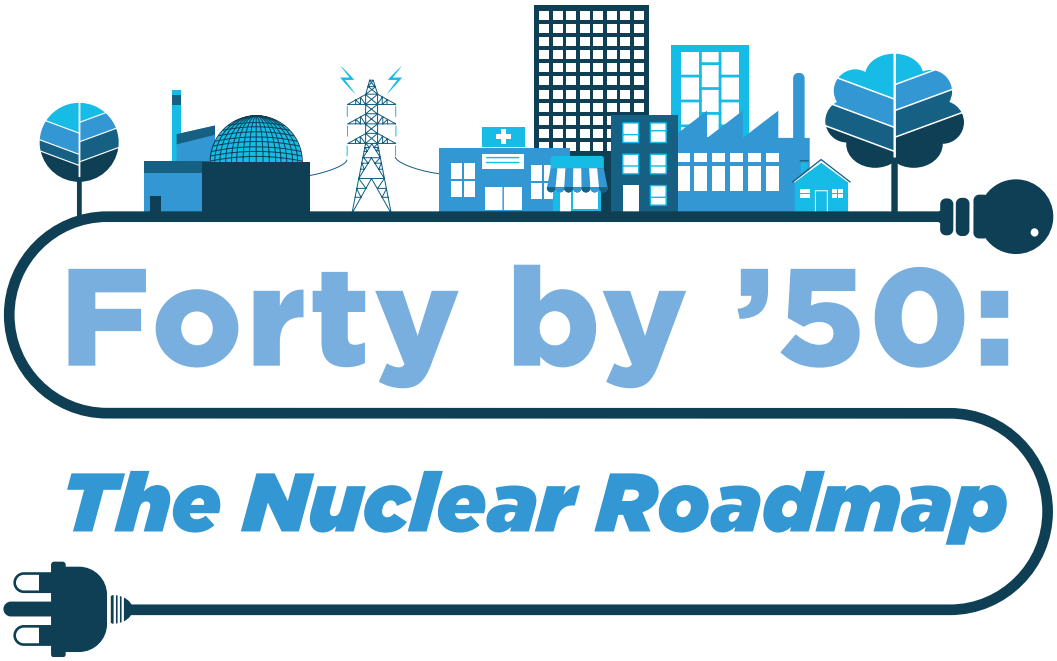


Forty by '50:

The Nuclear Roadmap

In June 2019 the UK's 2050 greenhouse gas emissions reduction target was increased from 80% to 'Net Zero', following the recommendation of the Committee on Climate Change (CCC). The Government is yet to publish a comprehensive plan or pathway to deliver this.

Nuclear power remains the only proven available source of reliable low carbon energy, delivering large volumes of electricity with the same lifecycle carbon emissions as offshore wind.[1] Nations and regions such as France, Ontario and Sweden which have successfully decarbonised have done so with a planned combination of renewables and nuclear power.

Nuclear also represents a multi-billion-pound economic stimulus opportunity as the country looks to rebound from the impact of COVID-19 and establish strong and enduring global trading relationships. By acting now, we can secure major domestic investment, maximise export potential and lock in a pipeline of engineering innovation which will deliver high quality, inspiring jobs for future generations, in every nation and region of the United Kingdom.

This report, compiled by the Nuclear Industry Association and industry members of the Nuclear Industry Council, sets out the potential contributions nuclear can make to our new national priorities, and the steps required to deliver them.

1] Lifecycle Carbon Emissions of Electricity Generation Sources, Energy for Humanity http://energyforhumanity.org/en/briefings/carbon-emissions/lifecycle-carbon-emissions-of-electricity-generation-sources/

Nuclear Industry Association

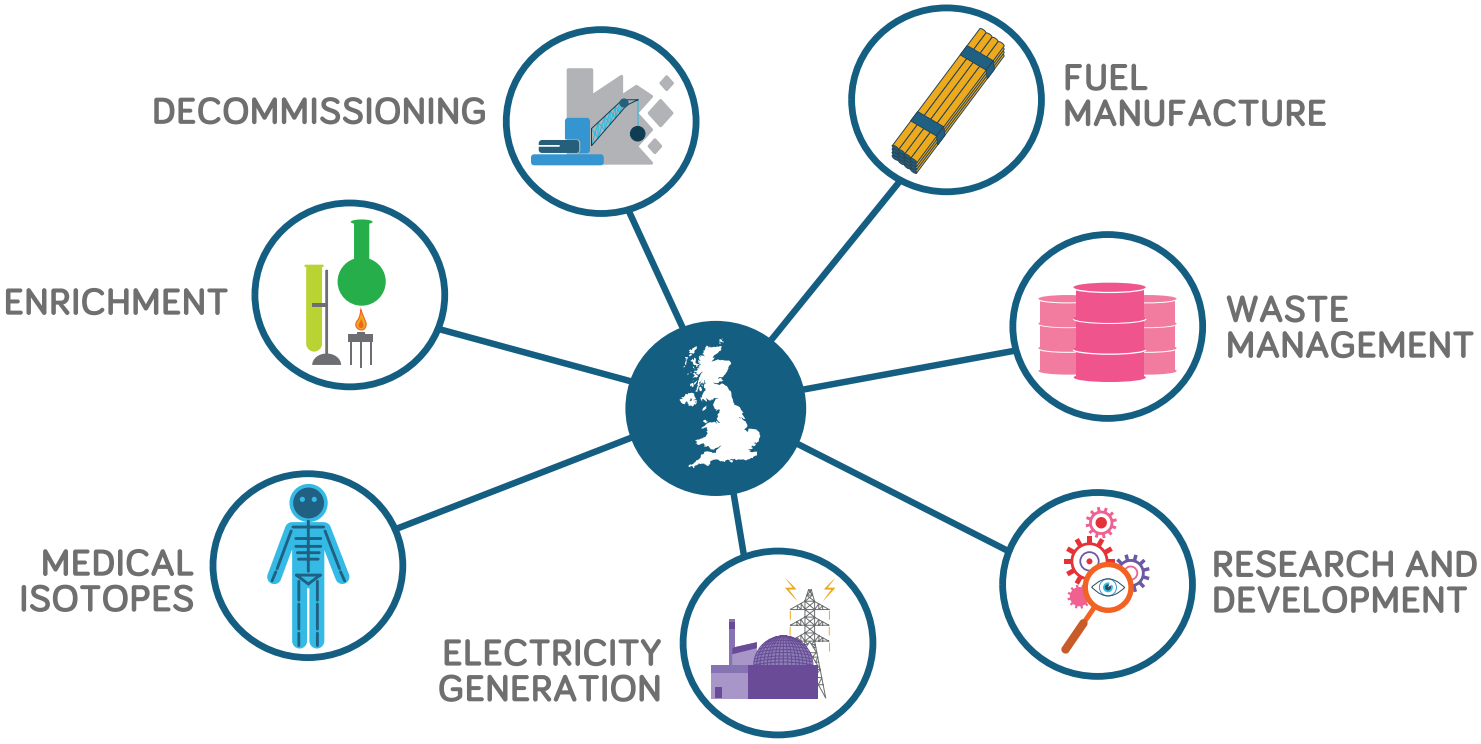
NET ZERO NEEDS NUCLEAR

The CCC's Net Zero Report cites the need for a quadrupling of clean electricity capacity by 2050, taking in decarbonisation of domestic heating and electrification of transport.

It identifies variable renewables as the major source of our electricity in 2050, contributing up to 57% of the mix, with 38% coming from 'firm' sources like nuclear.[2]

Today, nuclear fission provides nearly half of our clean electricity. Taking into account the entire end-to-end process from mining to decommissioning, it has the same carbon footprint as offshore wind, and a third that of solar power. It is non-weather dependent and its technical characteristics, unique amongst low carbon technologies, contribute to the stability of our national electricity grid.

Figure 1 *The UK Nuclear Industry 2020*



The UK civil nuclear industry has robust capability which has been developed and proven over decades, alongside a rich pipeline of research and development.

- Our current fleet, operated by EDF, is amongst the highest performing across the globe, **generating 40% of UK's domestically-generated clean electricity**, making a major contribution to national resilience and energy independence. The carbon savings from this is equivalent to taking a third of all cars off UK roads

- Urenco's facility in Capenhurst is a **world-leading uranium enrichment plant**, and Westinghouse's first-class Springfields site in Preston manufactures fuel for reactors operating in the UK, and across Europe.

2] Net Zero - Technical Annex: Integrating variable renewables into the UK electricity system, page 2, Committee on Climate Change, 2019 https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-Annex-Integrating-variable-renewables.pdf

- Spent fuel is managed with unparalleled expertise at Sellafield, pending the construction of a long-term geological disposal facility. Companies within the Nuclear Decommissioning Authority (NDA) estate, such as Sellafield Ltd and Magnox, have together developed a **world-class approach to the safe, efficient and innovative decommissioning** of our oldest power stations and other complex legacy facilities.

- The National Nuclear Laboratory and the Nuclear Advanced Manufacturing Research Centre are two key organisations responsible for **driving innovation to support nuclear's contribution to the future, net zero energy mix**. The UK Atomic Energy Authority in Oxfordshire, and others, are pioneering the technologies which will make nuclear fusion a reality.

- The industry currently **provides around 65,000 direct jobs**, extending to 160,000 when further job creation in the wider supply chain is included.

- Annually, the sector **contributes £6.2 billion in GVA** to the national economy, with £4bn being in the Northern Powerhouse area.[3]

All these activities happen under the scrutiny of independent regulators. The Office for Nuclear Regulation is internationally acknowledged for its excellence in regulating health, safety and security at nuclear installations with the Environment Agency and Natural Resources Wales enabling and enforcing strict local environmental discipline.

Based on a 'do nothing' scenario, from this decade onwards the contribution of nuclear power in the UK will shrink as the fleet of Advanced Gas-cooled Reactors closes, leaving only Sizewell B and Hinkley Point C when complete. Beyond 2050, it is likely that only Hinkley Point C would be operational.

Figure 2 *Today nuclear provides...*

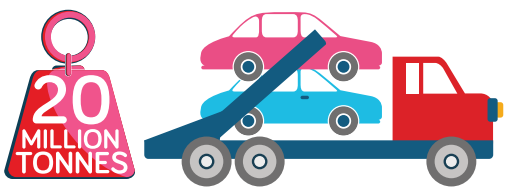
DEPENDABLE POWER

POWERING 1 IN 5 HOMES THROUGHOUT THE UK

PROVIDING 20% OF UK ELECTRICITY (AND 40% OF ALL CLEAN ELECTRICITY) 24/7 WHATEVER THE WEATHER

CLIMATE CHANGE SOLUTIONS

PREVENTING 20 MILLION TONNES OF CO_2 EMISSIONS IN THE UK



CURRENTLY PREVENTS 20 MILLION TONNES OF CO2 EMISSIONS A YEAR, EQUIVALENT TO TAKING A THIRD OF ALL CARS OFF UK ROADS

PROSPERITY & WELLBEING

SUPPORTING 160,000 JOBS ACROSS THE COUNTRY

SUPPORTING 65,000 DIRECT LONG TERM HIGH VALUE JOBS (AND A FURTHER 95,000 INDIRECT JOBS), CONTRIBUTING £6.2 BILLION IN GVA TO THE ECONOMY

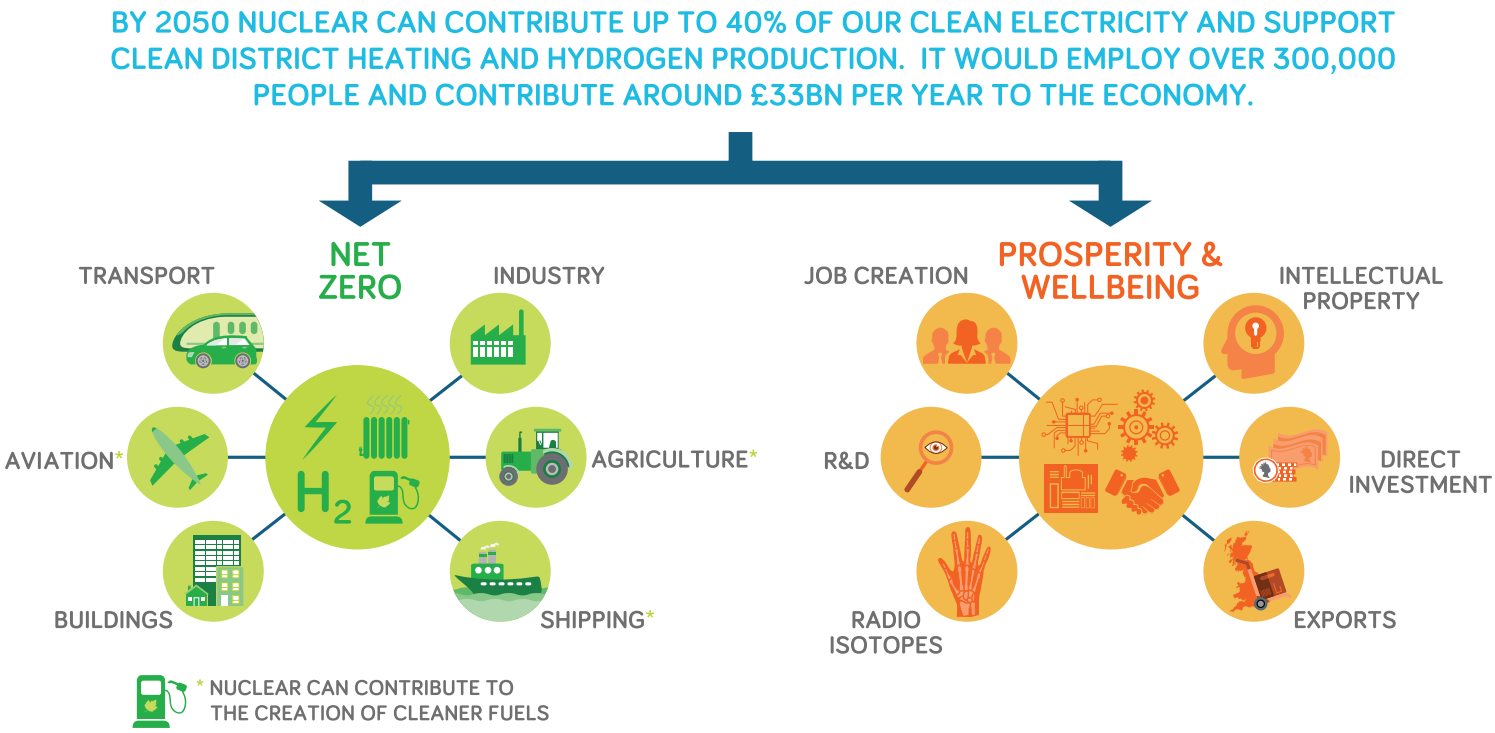
3] Activity Report, Nuclear Industry Association, December 2017 https://www.niauk.org/nuclear-activity-report/

NUCLEAR IN THE FUTURE: FORTY BY '50

In addition to the CCC's assessment on the need for firm, low carbon power, the Energy Systems Catapult (ESC), an independent innovation body, recommends both large and small nuclear in its 'Innovating to Net Zero' report.[4] Its modelling for a future energy mix ranges between 50% nuclear generation, and 28% in a scenario with greater deliverability of flexible and distributed generation.

Further to this, the ESC has a carried out a "deep dive" analysis using their Energy Systems Modelling Environment (ESME) tool. Titled Nuclear for Net Zero, it states an initial Government commitment to an optimised programme of 10GWe from large GW reactors to be a decision of low or no regret, enabling verdicts on continuing their development, or to begin the rollout of small and advanced reactors. Furthermore, ESME scenarios which deliberately exclude new nuclear place the system under enormous stress, with significant cost and land-take implications, whilst putting net zero at unnecessary risk.

Figure 3 *Forty by '50*



BEYOND ELECTRICITY

Nuclear power's potential extends beyond traditional electricity generation. There will be an increased role for hydrogen in our future energy mix for heating homes where direct electrification isn't possible, and to replace petroleum products in long-distance transport.

Either through electrolysis, or from the use of primary heat from nuclear power stations, nuclear offers an efficient, carbon-free alternative to producing hydrogen, one that doesn't rely on unproven technologies.

In aerospace, shipping, heavy freight and some agricultural uses—where pure hydrogen and batteries are unlikely to support decarbonisation—there is the potential to develop synthetic and lower carbon fuels, avoiding the need for major vehicle adaptation, through nuclear power.

4] Innovating to Net Zero: UK Net Zero Report, Energy Systems Catapult, March 2020 https://es.catapult.org.uk/reports/innovating-to-net-zero/

With appropriate system-based planning, wasted heat from both large and smaller scale nuclear plants could be used to power highly efficient district heating schemes for domestic and commercial spaces, as well as water heating.

In the wider energy sector, there is also significant potential to site electricity storage projects near nuclear sites. The UK has a strong history in co-locating such sites, such as the Dinorwig pumped hydro storage plant in Snowdonia near Trawsfynydd nuclear power plant.

As newer, innovative storage technologies develop, such as cryogenic liquid, ammonia, and molten salts; nuclear power stations, where grid connectivity is already in place, make ideal locations.

Beyond energy production, there is significant historic UK experience in producing medical radioisotopes for the NHS, however our supply is now reliant on imports. These are used for 750,000 treatments and diagnoses of life-threatening conditions every year.

PROSPERITY AND WELLBEING

A programme of nuclear new build, from large to small scale, would bring major strategic benefits to the UK including economic levelling up and global industry leadership opportunities.

Based on comprehensive modelling commissioned by the Nuclear Industry Association, we conservatively estimate the domestic value of a thriving nuclear sector to:

- Deliver up to **40% of the low carbon power** to a net zero economy;
- Be worth, by 2050, in excess of **£33 billion in Gross Value Added** per year;
- Provide well over **300,000 job opportunities**.

Large GW scale projects bring major investment, each with over 20,000 roles in construction, including around 700 apprentices per-project and over 800 long-term jobs during operation.

New nuclear projects have beneficial supply chain impacts on major strategic industries, for example UK steel, with 200,000 tonnes of Welsh steel being used on the Hinkley Point C project alone.[5]

The UK already plays a major role in the international decommissioning market, and this will only increase as other countries' plant also retire. Technologies and expertise developed in the UK have been successfully deployed in highly hazardous and complex sites around the world, saving those nations years of R&D, significantly reducing any further risks.

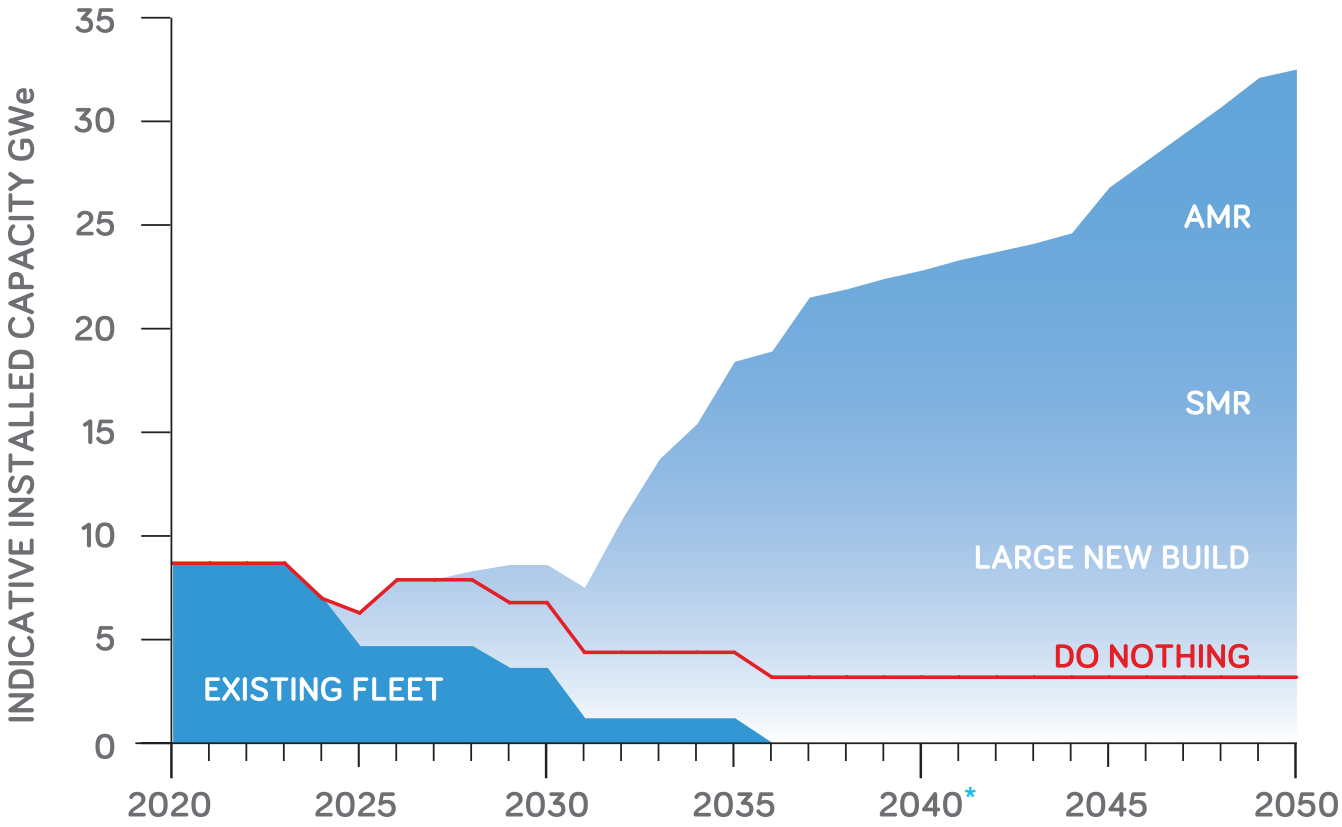
Our growing expertise in the next generation of nuclear technologies includes Small Modular Reactors, Advanced Modular Reactors, and Fusion, where we are already world leaders. This will enable the UK to develop and sustain a global leadership position, opening up new export markets, which Rolls-Royce estimates to be worth £188bn for their technology design alone.

As has historically been the case, a future investment programme in the nuclear industry will drive regional economic growth, innovation, and centres of excellence beyond metropolitan areas. The North West Nuclear Arc spanning from Anglesey in North Wales, across to Manchester and beyond to West Cumbria is well placed to benefit, along with the East and South West of England.

5] Hinkley Point: Welsh firm set for £100m steel deal, BBC News, 7 September 2016 https://www.bbc.co.uk/news/uk-wales-37299965

NUCLEAR CAPACITY TO 2050

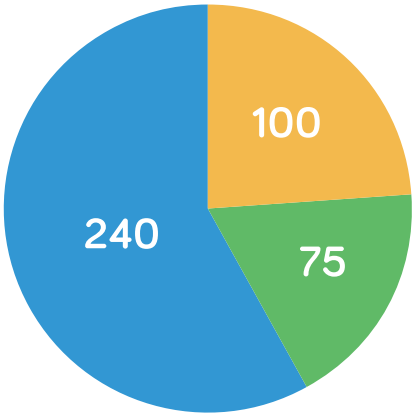
Figure 4 *Potential nuclear capacity to 2050*



* Delivery of a Spherical Tokamak for Energy Production (STEP) prototype reactor by 2040

Figure 5 *Deep decarbonisation in 2050 - beyond electricity*

415 TWh PER YEAR OF CLEAN ENERGY



TERAWATT HOURS PER YEAR

ELECTRICAL POWER GENERATED | POTENTIAL HYDROGEN GENERATED | POTENTIAL DISTRICT HEAT GENERATED

NET ZERO NUCLEAR ECONOMY

H_2 AN ADDITIONAL 18GW OF CAPACITY FOCUSED ON THE PRODUCTION OF HYDROGEN AND DISTRICT HEATING COULD FURTHER REINFORCE NUCLEAR'S CONTRIBUTION TO A NET ZERO ECONOMY

ON AVERAGE AVOIDING 186.75 MILLION TONNES OF CO_2 A YEAR—EQUIVALENT TO ANNUAL EMISSIONS OF 48 COAL-FIRED POWER PLANTS [6]

300,000 ADDITIONAL JOBS

£33BN ANNUAL GVA—GREATER THAN THE ENTIRE ELECTRICITY AND GAS INDUSTRY TODAY [7]

6] Greenhouse Gas Equivalencies Calculator, Environmental Protection Agency https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
7] Gross value added (GVA) of the United Kingdom (UK) in 2018, by sector, Statista, 27 May 2020 https://www.statista.com/statistics/285023/gross-value-added-gva-in-the-uk-by-sector

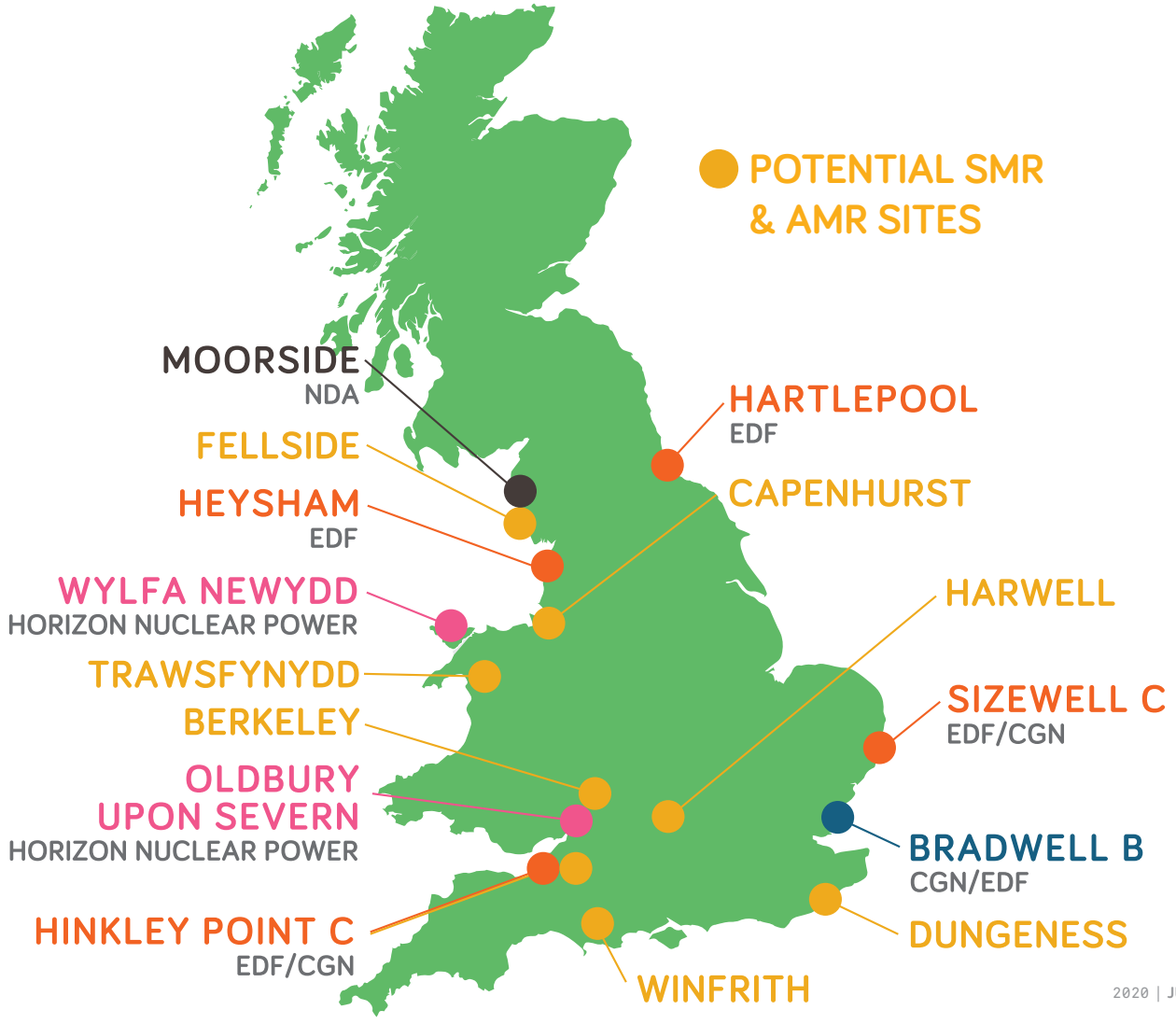
Reaching the capacity required to maintain nuclear's 40% share of the clean electricity market, and to generate the other fuels needed to meet net zero will require a significant programme of nuclear new build.

Figure 4 provides an indicative view of the types of deployable nuclear capacity.

This analysis does not attempt to prescribe a specific programme of new build, nor identify particular sites or projects beyond those already operational or in construction. However, it takes into account the following factors relating to the seven current sites earmarked for new nuclear build of over 1GW in size, and their current owners:

- **Bradwell B** – China General Nuclear (CGN)/Electricité de France (EDF)
- **Hartlepool** – EDF
- **Heysham** – EDF
- **Hinkley Point C** – EDF/CGN
- **Moorside** – Nuclear Decommissioning Authority (NDA)
- **Oldbury upon Severn** – Horizon Nuclear Power
- **Sizewell C** – EDF/CGN
- **Wylfa Newydd** – Horizon Nuclear Power

Figure 6 *Nuclear new build sites*



Given the right conditions EDF intends to build two 1.6GW European Pressurised Water Reactors (EPR) at Sizewell to add to the two under construction at Hinkley Point C. Horizon Nuclear Power would, in the right circumstances, build multiple gigawatt-scale reactors at Wylfa and Oldbury and CGN has expressed an intent to develop six 1.1GW HPR1000 reactors, starting with two at Bradwell.

Should these projects go ahead, and the sites be developed to their maximum potential, it would create a strong platform of around 18-19GW of low-carbon, dependable, long-term power plants to replace our retiring fleet, whilst maintaining the health of the nuclear supply chain, which will be essential to introduce newer technologies, including fusion.

Figure 4 also assumes a significant build programme of Small Modular and Advanced Modular Reactors which could be co-located on existing sites, creating cost synergies, for example through co-licensing and operation, or on bespoke sites identified for such smaller technologies.

REDUCING COSTS

By both minimising construction risks through replication, and applying a new financing framework, the overall costs of new nuclear can be significantly reduced.

The cost of capital currently represents up to two-thirds of a nuclear project, a price which is ultimately borne by customers through their electricity bills.

A £1bn reduction in the construction cost (c5-7%) would take around £2-3/MWh off the cost to the customer; whereas just a 1% reduction in the cost of capital would reduce this by £8-9/MWh.

Addressing the costs of both construction and financing would make **c£60/MWh** achievable for the next wave of plants, reducing to **c£40/MWh** for further units.

Such sites have been identified in Figure 6. These are locations which should be considered in a National Policy Statement, and subsequent public consultations, for the siting of small and advanced reactors. This is by no means an exhaustive list, for example Urenco's Capenhurst has been listed as it is a nuclear licenced site with onsite energy demand, which with the right licencing changes could run its enrichment facility off a small reactor. However, there are several other non-nuclear industrial sites across the country with similar onsite demand for energy, both thermal and electrical, which could benefit from hosting an SMR/AMR.

Futhermore, consideration should also be made for how former fossil-fuelled brownfield sites could host SMRs or AMRs.

There are several UK companies and consortia which are well-placed to develop SMRs and AMRs. These include Rolls-Royce, Moltex Energy, U-Battery and Westinghouse. Internationally, the USA, Canada and China are actively pursuing development pipelines, including designs by NuScalePower, GE Hitachi and the China National Nuclear Corporation. There is strong interest from international players in the UK market, including opportunities to localise content.

Many of these reactor designs go beyond traditional nuclear generation, as several are capable of using plutonium as fuel. The UK is home to the biggest global stockpile of this material, which is awaiting a long-term disposition decision from the Government. Other designs, due to their modular and trans-portable nature can be used at energy-intensive business clusters, providing multiple industrial uses.

TURNING ASPIRATION INTO PROGRESS

The amount of new nuclear capacity required to meet net zero is substantial, and building it alongside other major infrastructure programmes will require determination, commitment and planning from both industry and Government, focused on the following steps:

1. The nuclear industry must continue to drive down costs of new build projects (30% by 2030) and establish delivery excellence.
    - A well-disciplined, programmatic approach using repeated designs and an experienced supply chain should be the focus, capitalising on the Nuclear Sector Deal's activity, taking real-time supply chain learnings from Hinkley Point C.
    - Next generation reactors will be nascent technologies. However, their modular designs and simpler, shorter construction programmes, combined with opportunities for co-location with other facilities, will bring down costs.
2. The Government should articulate a clear, long-term commitment to new nuclear power.
    - There are opportunities to do this in the upcoming Energy White Paper, and in the National Infrastructure Strategy.
3. Progress must also be made on an appropriate funding model for nuclear new build to stimulate investment in new capacity and reduce the cost of capital.
    - This could be a Regulated Asset Base model, direct Government investment, or an alternative which could also be used on other large infrastructure projects required to reach net zero.
4. A National Policy Statement on small reactors.
    - A detailed policy and a facilitative programme should be developed to remove barriers to the delivery of Small Light Water Reactors and AMRs including siting, generic design assessment slots, site licensing and operational models.
5. Support the 2030 targets of the Nuclear Sector Deal:[8]
    - Demonstrating progress on delivering a 20% reduction in the costs of decommissioning;
    - Driving down the cost of new build projects by 30%;
    - Ensuring 40% of the nuclear workforce is female;
    - Winning up to £2 billion domestic and international contracts;
    - Announcing which technologies have qualified for the next round of funding in the AMR competition.

8] Nuclear Sector Deal Policy Paper, Department for Business, Energy & Industrial Strategy, 27 June 2018 https://www.gov.uk/government/publications/nuclear-sector-deal

6. Industry and Government should agree a framework and commitments, focused on cross-sector collaboration.

    - This would develop the potential for nuclear to support advanced decarbonisation pathways.

    - It would also include the production of medical isotopes, hydrogen, and synthetic fuels for transport, along with heat applications including district heating and agriculture and storage technologies.

CONCLUSION

Nuclear power has been providing clean, stable electricity to UK homes, hospitals and businesses since 1956. It has continued to evolve and has the potential to do this for generations to come and much more besides.

It is also capable of socioeconomic transformation which, combined with cost reductions, delivers genuine value for money, particularly once the whole system costs of integrating variable renewable technologies into the electricity network are factored in.

With the closure of UK coal power stations and the progressive closure of the Advanced Gas-cooled Reactor fleet, the UK is losing diversity and resilience. Doing nothing means losing our nuclear capability and expertise, which is amongst the best means we have available to meet our national economic and environmental goals.

Alternatively, the UK can capitalise on a proven, reliable technology source. A fleet of new nuclear stations can complement renewable generation, helping to avoid over-dependence on real-time imports (in the form of either electricity or gas) at times of low sun and wind, providing valuable stability to our national grid.

It would not only deliver a dramatic reduction in emissions, but galvanise our efforts to forge a prosperous zero carbon economy, right when we need it most, demonstrating global leadership as co-hosts of COP26.

The Nuclear Industry Association (NIA) is the trade association for the civil nuclear industry in the UK, representing more than 250 companies across the supply chain. The diversity of NIA membership expertise in new build, management and decommissioning enables effective and constructive industry-wide interaction.

Rediscover NUCLEAR

#RediscoverNuclear

NIAUK.ORG

Follow us: @NIAUK

Prepared for:

nuclear industry council

Nuclear Industry Association is a company limited by guarantee registered in England No. 2804518

Registered Office:
5th Floor, Tower House
10 Southampton Street
London WC2E 7HA
TEL +44(0)20 7766 6640
EMAIL info@niauk.org