ENERGY

NUCLEAR BUILD
A VOTE OF NO CONFIDENCE?

Institution of MECHANICAL ENGINEERS

Improving the world through engineering

THE ENERGY SECTOR NEEDS TO BE MORE CONFIDENT THAT GOVERNMENT IS COMMITTED TO A LONG-TERM NUCLEAR POWER FUTURE BEFORE IT WILL INVEST ITS MONEY IN A NEW NUCLEAR BUILD PROGRAMME.

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With only forty years to reduce our greenhouse gas emissions by 80%, the UK Government has recognised the need for a new nuclear build programme. This will provide the extra electricity needed to help transition sectors, such as transport and built environment, to low-carbon alternatives. However, until the nuclear industry is fully confident that the Government is committed to a long-term nuclear future, it is unlikely to commit the billions of pounds of investment needed for a new wave of nuclear power stations.

This report proposes a number of recommendations which could help bridge the confidence gap between industry and Government and help the nation achieve its long-term low-carbon targets.

This report has been produced in the context of the Institution's strategic themes of Energy, Environment, Education and Transport and its vision of 'Improving the World through engineering'.

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EXECUTIVE SUMMARY

A LOW CARBON FUTURE: THE REALITY, THE MYTHS AND THE CONCERNS

In 2008, the UK became the first country in the world to pass a law to tackle climate change, namely the Climate Change Act. The first legal document of its kind, the Act set targets for reducing our greenhouse gas (GHG) emissions by 80%, relative to 1990 levels, by 2050. It also set an intermediate target of 34% GHG reduction by 2020.

For the UK to achieve the 2020 and 2050 targets, all sectors of the economy will need to play their part in reducing GHG emissions. The energy and transport sectors, which between them account for over 50% of GHG emissions, are of particular concern due to their heavy reliance on fossil fuels.

The Institution firmly believes that it is the role of Government to provide leadership and commitment to industry if these tasks and targets are to be achieved. The relationship between industry and Government must be one which is built upon trust and confidence. The Institution believes that in the case of nuclear new build this confidence is not as strong as it needs to be and proposes, via the recommendations made in this report, solutions to help correct this situation.

These include the provision of enabling support and actions to encourage sectors to transition to low-carbon alternatives, including the reduction of red-tape and removal of obstructions which inhibit investment. We also recommend clear communications with the public and industry about the reasons why we need to achieve these ambitious targets, even if they are not popular.

The depth of the financial crisis over the last 18 months has had an impact on all global economies. The UK, in protecting its economy, has accumulated substantial levels of debt. Furthermore, the failure of the UNFCCC Conference of Parties (COP15) in Copenhagen at the end of 2009 to achieve a legally binding emissions reduction agreement, and subsequent public debates about the possible manipulation or misrepresentation of climate change data, has led to a growing public scepticism about the significance of man-made global warming. As a consequence, the impetus for reducing GHG emissions has declined.

Finally, the UK is on the verge of entering what is likely to be a closely fought General Election. The Institution is concerned that relatively short-term concerns will dominate the political agenda for all parties, leaving the longer term issue of climate change as a lower priority.

If this is the case, industry may well perceive the Government's good intention towards a low carbon economy as nothing more than that. For the nuclear energy sector in particular, to have the confidence to invest tens of billions in new plant or technologies, it will need strong and binding commitment, delivered in actions that will last over the life of the investment, from whichever Party enters into power.

IN SUMMARY

- The UK has committed to reducing GHG emissions by 80% by 2050.
- Government needs to provide leadership and commitment to achieve this ambitious target.
- The energy sector needs confidence in the Government's long-term commitment to the nuclear industry before it invests billions in building new nuclear power stations.

OUR NUCLEAR HERITAGE: THE 50 YEAR CYCLE

The UK was a pioneer in nuclear power development with the world's first civil nuclear power plant opening at Calder Hall in 1956. The Government was convinced that nuclear power could provide a reliable and large base-load electricity generation for the nation.

For a further thirty years the UK continued to bring additional nuclear plants online providing around one fifth of the nation's electricity needs. However with growing concerns over waste, escalating costs and the accidents at Three Mile Island and Chernobyl, public enthusiasm and confidence in nuclear power waned by the mid 1980s.

By the 1990s nations such as Germany and Spain had voted to remove the nuclear element from their energy generation mix, opting for fossil and renewable options. With growing public hostility to nuclear power, the UK chose not to take a similar path but instead to suspend effectively any future nuclear projects, opting to rely on coal and our North Sea oil and gas reserves for electricity generation.

By the start of the 21st century with awareness of global warming, and the need for the world to reduce its GHG emissions, together with concerns about the costs, security and future availability of fossil fuels, many nations began to reconsider the use of nuclear power. Furthermore, for the UK, there was a growing concern that our existing conventional and nuclear power generation plants would need replacing in the very near future.

With the passing of the Climate Change Act, the power sector and the Government recognised that to achieve these ambitious targets, new nuclear power would have to be a significant contributor, alongside large-scale deployment of renewables and some fossil fuel generation allied with Carbon Capture and Storage (CCS) technologies.

Renewable energy technologies, such as wind and wave/tidal power, were given additional importance due to their zero GHG emissions. To date unresolved issues relating to costs and financing, the delayed introduction of feed-in-tariffs, planning processes and intermittency of supply, have significantly slowed their acceptance and large-scale implementation. Carbon Capture and Storage for continued fossil fuel generation has also been prioritised (this technology aims to remove CO_2 emissions from fossil fuel power stations and place the emissions underground in secure geological formations). This technology is still at early developmental stages and the economics of commercial deployment are uncertain.

CONFIDENCE AND RISK: A LEAP OF FAITH

In 2008, Business Secretary John Hutton announced what promised to be a large-scale future programme of nuclear build for the UK. Unlike any other nation at that time, this programme would be 100% financed and supported by the energy sector. The Government intimated that, consistent with its non-interventionist free market approach, it would play its part as a market 'enabler' by reducing or removing any barriers impeding the build programme. In doing so, it created the Office of Nuclear Development to assist.

Further to this announcement, while being clear that it would not put an upper or lower cap on what industry could deliver, the Government set-out its aspiration for the new build to generate approximately 25 GW of electricity. The expectation that this large-scale capital investment, with its high up-front costs, must be delivered by the market, has led to the aspiration being deemed unrealistic by industry. By 2010 the utilities had cut back their nuclear build connection plans by 28% to 18.4 GW with a possibility that this may further reduce to only 13 GW when final decisions are taken. The Institution believes key to this is a lack of confidence in the Government's commitment to a long-term nuclear build.

The cost of developing one nuclear power station is estimated to be between £3.5bn and £5bn at today's prices. Companies willing to invest heavily in a new nuclear build want a higher probability of return on such an investment, and surety that Government would remain committed to a nuclear future. The current lack of confidence in Government has mitigated against such investment.

This underinvestment is exacerbated by major uncertainties surrounding individual site planning, grid connection, licensing, waste and finance which need to be resolved without further delay and excessive consultation.

IN SUMMARY

- Nuclear power is vital to the UK's future low-carbon energy mix.
- Unresolved issues in planning and tariffs has delayed all elements of the energy mix.
- The large capital investment required in the energy sector is not happening.

FUTURE TRANSPORT AND THE SECOND WAVE

A substantial number of reports, debates and media hype has been dedicated to converting the nation's transport sector to low-carbon alternatives. It is generally agreed that one solution would be to reduce the transport sector's reliance on fossil fuels. There is a growing consensus that this will require a significant reduction in journeys alongside electrifying a substantial part of the UK's railway network, and offering the public electric and hybrid vehicles with a suitable, robust and widespread charging network.

However, if this ambition is to be realised, substantial extra electricity generation will be required. The Institution of Mechanical Engineers UK Energy 2050 report of 2009 estimated that the UK would need to double its current electricity generation capacity to meet the nation's low-carbon aspirations, including those for transport, space-heating and industry, discounting any demand reduction.

To double the electricity generation capacity and offer a reliable, secure power supply, the UK, in addition to pursuing the large-scale deployment of renewables, will either have to sustain or increase its reliance on fossil fuel generation, or commit to a second-wave of nuclear build from 2025 onwards. Questions however remain about how to match the inflexible base-load of nuclear generation and the intermittent demand of electrified transport.

If a surety was granted to a second-wave of nuclear build, this would offer some immediate benefits. It would provide additional confidence to the nuclear industry that a realistic vision for electricity supply was emerging through to 2050 that included a base contribution in the future generation mix from a nuclear build programme. In simple terms, to ensure the UK has a reliable base-load capacity, Government should set an aspirational 2050 target now for the proportion of electricity produced by nuclear.

With such a commitment to a nuclear power requirement, industry and academia could plan for the extra resources needed (finances and the supply chain requirements), incentivise and atrract more skilled engineers and technicians into the sector, plan the number of future plants required, and see the UK as a secure and long-term market for investment.

ENGINEERED IN BRITAIN

Currently, the nuclear build plans offer only limited opportunities to the UK manufacturing sector. With no nuclear build in the country for over twenty years, many of the manufacturing skills have left the nation.

Since most components and resources can be sourced relatively easily from around the world, it is unlikely that the first-wave new-build will lead to a large-scale revival of the UK nuclear manufacturing sector. With proposals taking shape in 40 nations for parallel new build programmes, a global supply bottleneck is likely to emerge. A commitment to a future second wave does open many possibilities for the UK to establish local capability against an ongoing demand. A second-wave would mean the biggest commercial nuclear build programme ever undertaken in the UK and could act as a much needed resurgence to British manufacturing, an area in which the UK was once a global leader.

Today, the UK is still the sixth largest manufacturing nation in the world. It is recognised for having highly skilled and trained engineers and technicians. By having a long-term committed nuclear build project, manufacturing companies could invest in new services and products to assist in the building of a new nuclear fleet. Indeed, the Government could reasonably encourage all nuclear build consortia to adopt the US Westinghouse philosophy of 'We buy where we build'.

The Institution believes that UK Government should offer 'confidence building' incentives, such as loan guarantees or guaranteed minimum carbon-pricing. Furthermore, Government should encourage a percentage of manufacture and build to be UK sourced.

Finally the UK is still considered the 'gold standard' for nuclear safety. To have a nuclear plant certified in the UK, rigorous and fault free manufacture and development is required. Used effectively, UK manufacturers could utilise this level of compliance to pass UK regulations and promote their products as 'Engineered in Britain'.

IN SUMMARY

- The UK will need to double its electricity generation capacity by 2050, requiring a commitment to a second-wave of nuclear power now.
- A global bottleneck in supply could derail the current plans for nuclear build.
- Measures such as loan guarantees or setting guaranteed minimum carbon pricing would improve confidence and create wealth.

RECOMMENDATIONS

The Institution of Mechanical Engineers urges Government and other key stakeholders to consider the following three recommendations to ensure the UK's ambition to transition to a low-carbon economy can be met.

1 **For Government to initiate and demonstrate leadership and commitment to the UK nuclear build programme by resolving key enabling issues including planning, grid connection, nuclear waste, and offering loan guarantees or setting a minimum carbon price**. This authoritative approach by Government (without the need to invest directly in the sector) would give the nuclear consortia the confidence to invest nearly £50bn into the UK and help transition the UK to a low-carbon economy.

2 **For Government to show clear commitment to a second-wave nuclear new build programme beyond 2025**. This phase is crucial if the UK wishes to transition its transport sector (namely road and rail) and the built environment towards electricity, and encourage the development of a reinvigorated UK manufacturing base, positioned to exploit the substantial nuclear new build markets emerging worldwide.

3 **For Government to identify 'vital occupations' needed for the nation's future low-carbon development with the nuclear power industry being one such occupation. Such nationally critical occupations should be financially incentivised, including course fee repayment, to bring in the necessary quantity and quality of talent to these professions**. The Institution believes it essential that the UK develops skilled engineers and technicians required to build, maintain and ultimately decommission nuclear power stations. This is central to it maintaining the 'Gold Standard' reputation for quality and safety.

This report presents the analysis and recommendations of expert members of the Institution of Mechanical Engineers and a list of the contributors can be found on page 20.

FOR THE UK TO HAVE A REALISTIC CHANCE OF REDUCING GHG EMISSIONS BY 80% BY 2050, ELECTRICITY GENERATION MUST BE ALMOST ZERO CARBON EMITTING BY 2030.

THE CONFIDENCE TO ACT, THE CONSEQUENCE OF FAILURE

A FUTURE LOW CARBON ECONOMY

Britain is gradually moving from a coal, oil and gas based economy to a largely electricity based economy. Electricity generation costs that once closely tracked the coal supply market in the 1950s and then the oil supply market in the 1970s, have shifted again and are now driven by the natural gas market, the marginal price-setting fuel of the 1990s and 2000s[1]. But these carbon-intensive energy solutions that empowered the 20th century have imperilled the 21st.

Over the next 40 years the Climate Change Act 2008 aims to deliver an 80% cut in UK greenhouse gas (GHG) emissions by 2050, relative to 1990 levels[2]. Hydrocarbons' days as the world's leading energy resource are numbered. Making the transition will not be easy. Reducing the GHG emissions of Britain's energy infrastructure will require unprecedented levels of investment and profound changes to the way that electricity is generated, distributed and consumed.

For the UK to have a realistic chance of reducing greenhouse gas emissions by 80% by 2050, electricity generation must be almost zero carbon emitting (decarbonised) by 2030[3].

THE LOW CARBON ENERGY TRILOGY

To reach our climate change targets, a trilogy of nuclear generation, renewable generation and some fossil fuel generation allied with Carbon Capture and Storage (CCS) technologies are considered by Government as the best route forward.

Renewable energy has had considerable focus over the last ten years and been consistently supported by the Institution of Mechanical Engineers as a desirable way forward towards a sustainable future. The Government has been keen to encourage the development of wind, wave and tidal electricity production due to its zero carbon emissions potential. However, uptake of these technologies has been hampered by planning, cost and financing. It is recognised that renewable energy technologies, especially those exploiting wind and wave sources, suffer from intermittency issues which for large-scale deployment urgently need to be solved, possibly through the implementation of SMART grid and energy storage technologies currently in the development phase.

With regards to Carbon Capture and Storage (CCS), the UK Industry Taskforce on Peak Oil & Energy Security (ITPOES) considers CCS technology to be at least a decade away from the prospect of commercial deployment. There is no demonstration project today that shows industrial-scale deployment is even feasible, much less economic[5]. In recent years the Institution has been consistently recommending greater emphasis be placed in this area to ensure the timely availability of CCS for commercial deployment. As a historical rule of thumb, major technology transitions generally take decades to upscale from the laboratory to real-world commercial deployment[6]. The UK electricity industry has only 20 years to decarbonise by 2030.

In the short-term, Britain appears to face a choice of either a dash-for-gas (without CCS) or a dash-for-nuclear in the race to meet electricity demand requirements up to 2030. The "trilogy" approach means that a judgement is desirable so that, in the near-term absence of deployable SMART grid and energy-storage technologies, the more flexible gas plants can be operated to balance the intermittency of the renewables as they are brought on-line. In the longer term, these gas plants must either be retrofitted with CCS, replaced by others constructed with CCS or replaced with new technologies.

Today, nuclear power is recognised as a reliable large-scale base-load generation technology that can produce electricity continuously without significant operational carbon emissions. In a world of few viable large-scale technological alternatives, nuclear can help decarbonise Britain's energy infrastructure and it is a cornerstone of the Government's 'UK Low Carbon Transition Plan'[6].

THE NUCLEAR NEW BUILD: FACT AND FICTION

The strategic direction of travel needed to decarbonise our nation is clear. However, the speed of implementation is not. All transitions take time to implement successfully. Despite ambitious aspirations, there is increasing evidence that Britain's recently revived nuclear trajectory is already stalling.

Following publication of the 2008 'White Paper on Nuclear Power'[7], electricity utility companies formally applied to connect up to 25.6 GW of new nuclear capacity to Britain's national electricity grid by 2025[8]. But this ambition has not been matched by business reality. By the beginning of 2010 the utilities have cut back their nuclear build grid connection plans by 28% to 18.4 GW[9]. Realistically perhaps only 13 GW may actually be financed and constructed by the private sector, as illustrated in **Table 1**. This reduction in scale comes at the time of a looming UK energy gap which many experts expect by the middle of this decade.

Recently there has been a noticeable shift in the Government's nuclear policy language away from whether first-wave sites are physically 'deployed' by 2025, towards whether sites are simply 'deployable' by 2025. The distinction is important as it indicates that, in line with Government's non-interventionist free-market thinking, the responsibility for financing and constructing the plants is clearly still with the generating utilities and not the Government.

As financial analysts Citigroup have pointed out, energy utility applications for planning consent do not amount to firm nuclear build plans[10]. Because the capital costs of nuclear power plants are very high, it makes good commercial sense for the Investment Boards of nuclear utility parent companies to delay their investment decision until the last possible moment. In the absence of a robust and effective carbon pricing regime, the utility companies need to feel confident that the UK has a long-term stable commitment for nuclear power which will allow them to recoup the sizeable investment that is needed to build the first-wave.

As a result of the Government's free market approach to the energy sector and its failure within that framework to signal adequately its long-term commitment to nuclear, along with renewables and CCS, it is increasingly likely that a second carbon intensive dash-for-gas will be needed to fill the energy gap that will emerge around 2015. As France and Japan have demonstrated, the costs of nuclear power are such that only a full-blown UK build programme can reap sufficient economies of scale to compete with gas-fired generation technology in the absence of effective carbon trading. In one sense, nuclear power is an all-or-nothing option[11].

In comparison with the financial rescue of British banks, little attention has been paid to the carbon market. As a nation, Britain has invested far more on avoiding financial catastrophe than climate or energy catastrophe.

According to the National Audit Office, by the end of 2009 the Treasury's gross outlay was £131 billion to support the UK banking system[12]. For comparison, at today's prices, this outlay would be sufficient to construct around 30 nuclear reactor units[13].

IN SUMMARY

- Nuclear new build is vital for the UK's low-carbon economy aspirations.
- Initial industry commitment to 25 GW nuclear build is likely to reduce to around 13 GW.
- The barriers are still too high for the private sector to invest.
- Government must do more to build market confidence.

THE CONFIDENCE GAP

We need to commence our nuclear build now. The Government wishes to transition to a low-carbon economy but is not willing to finance the move. It will be for the utility companies to decide if they wish to invest long-term in the UK. It will therefore be their decision to decide the capacity build in the future and, ultimately, if the UK will meet its 2020 and 2050 GHG emission targets.

Before they commence with any large-scale construction which would cost tens of billions, utility companies need to be confident that the UK has a long-term commitment to nuclear power. With possible additional gas reserves becoming available over the next few years, especially from North America, the utility companies will not want to be caught with costly plants which cannot make a return on their investment.

The Government, in its commitment to nuclear, promised to clear the path. To date, many companies still have unresolved concerns about enabling measures including planning, grid connection, licensing, waste and finance.

For the nuclear companies to begin what will be the biggest nuclear-build in the UK's history, the companies need to see more commitment and leadership by Government. They need Government to clear the path and demonstrate long-term (possibly 40 years+) commitment to these companies and the nuclear programme.

To overcome the pressures on public finances, the Government does not have to fund the low-carbon transition of the UK economy. The Government could offer utility companies the option of guaranteeing loans, an approach recently announced by President Obama for the construction of two new nuclear power stations in the United States. Alternatively, Government could introduce a guaranteed minimum carbon price. These actions would offer a long-term low-risk commitment by Government while instilling confidence in the sector and attracting the large investment needed for building the new fleet of nuclear power stations.

RECOMMENDATION ONE

For Government to initiate and demonstrate leadership and commitment to the UK nuclear build programme by resolving key enabling issues including planning, grid connection, nuclear waste, and offering loan guarantees or setting a minimum carbon price. This authoritative approach by Government (without the need to invest directly in the sector) would give the nuclear consortia the confidence to invest nearly £50bn into the UK and help transition the UK to a low-carbon economy.

Draft National Policy Statement (NPS) Nuclear Build Site	First Nuclear Connection Date	First Registered Capacity (MW)	Maximum Registered Capacity by 2025 (MW)	IMechE Estimate of Actual Build by 2025 (MW)
(Dungeness)*	(2016)	(1,650 MW)	(1,650 MW)	—
Hinkley	2017	1,670 MW	3,340 MW	3,260 MW
Sizewell	2020	1,670 MW	3,340 MW	3,260 MW
Oldbury**	2023	1,600 MW	1,600 MW	—
Wylfa	2020	1,200 MW	3,600 MW	3,260–3,462 MW
Bradwell	2021	1,670 MW	1,670 MW	—
Heysham	2022	1,650 MW	1,650 MW	—
Sellafield	2023	1,600 MW	3,200 MW	3,260–3,462 MW
Braystones	None	None	None	—
Kirksanton	None	None	None	—
Hartlepool	None	None	None	—
Totals	**None**	**11,060 MW**	**18,400 MW**	**13,040–13,464 MW**

Table 1:
Proposed Nuclear Build Sites and Registered Generating Capacity by 2025[15, 16]

*The Government has proposed to reject new nuclear build at Dungeness, which was nominated for development by energy companies in March 2009

**Development of Oldbury has been ommitted due to cooling capacity issues

THE SECOND NUCLEAR WAVE

BRITAIN'S DOUBLE PEAK NUCLEAR RENAISSANCE

Britain possibly faces two different kinds of nuclear renaissance. These have important consequences both for meeting the UK's decarbonisation objectives and the capacity of the nuclear engineering supply chain in Britain.

The first-wave nuclear renaissance that is currently envisaged to take place between now and 2025 effectively 'replaces nuclear with nuclear'. All but one of Britain's ten operating nuclear power stations are scheduled to close by 2023. Britain's existing 11 GW nuclear fleet would be replaced with new PWR reactors as existing AGR and Magnox stations reach the end of their operating lives.

Despite efforts to reduce consumption and improve efficiency of use through behavioral change, both of which the Institution strongly advocates, likely increases in electricity demand during this period means that the overall percentage of nuclear in the UK generation mix will actually fall. The first-wave deployment is therefore unlikely to make any significant impact on delivering the UK's low-carbon objectives.

A second-wave nuclear renaissance that might take place beyond 2025 could be of strategic significance for the UK in meeting it's 2050 GHG reduction target. The second-wave would essentially mean 'replacing coal with nuclear', increasing the share of nuclear electricity generation from the present level of 14% (48 TWh nuclear produced from a total of 351 TWh generated in the UK) up to around 35–40% beyond 2030, as proposed by the Wicks Review.

It seems most likely that gas-fired generation with a gradually increasing contribution of renewable generation will dominate the UK's electricity mix for the foreseeable future. Oil-fired generation will probably become further marginalised within the UK, serving mainly as a small-scale option for remote consumers who must rely on diesel generators.

The major long-term question is whether, in addition to renewables, the UK power sector will choose either to expand nuclear power generation or follow the alternative path of selecting coal-fired generation with carbon capture and storage technology. Although both routes to a low-carbon economy could be pursued simultaneously, market forces generally tend to select a particular technology as the 'winner' which then eventually comes to dominate market share.

This is an inevitable consequence of any market-based system because private investors must concentrate their limited financial resources on just a few technologies judged to have the best prospects for commercial success. Selection is rarely based on technical merits alone (VHS vs Betamax for example). Green groups call this effect the crowding-out of energy investment.

It is difficult to predict the likely proportion of renewable energy or fossil fuel with CCS by 2030 until we fully understand how much of each technology will be successfully commercialised and witness large-scale deployments. Certainly both have powerful supporting lobbies within Whitehall. What is clear is that the decision will primarily be made by the private sector and will therefore be based on the lowest risk with the greatest profit.

The Government's 2008 'White Paper on Nuclear Power' makes clear that nuclear development is not really a decision for Government at all because "It will be for energy companies to fund, develop and build new nuclear power stations in the UK, including meeting the full costs of decommissioning and their full share of waste management costs"[19].

Under the current free market framework, the Government's primary role through policy making and regulation setting is mainly as a market enabler rather than a market decision-maker. This 'hands-off' approach includes taking 'enabling' support actions, such as funding demonstration plants for CCS and encouragement to make offshore wind farms more economically attractive with subsidies in the form of double Renewable Obligation Certificates (ROCs).

REPLACING NUCLEAR WITH NUCLEAR

From the position of the current realistic nuclear build expectation, this will only have a minimal impact on reducing Britain's carbon emissions from electricity generation. This first-wave build can be mostly resourced from within the existing engineering labour pool of British expertise, provided that newly qualified engineers replace the 5% of the workforce due to retire each year between now and 2020.

The first-wave expectation is not enough to stimulate serious corporate investment in further developing the engineering skills base. The UK has a world-wide reputation for engineering excellence resulting in strong global demand for British engineers. Britain knows how to build major infrastructure projects and enjoys a dominant position in the export market for engineering skills.

This market is extremely important to the contracting community, particularly for British consulting engineering services whose exports typically earn half of company turnover. But the down-side is that UK firms tend to have an over-supply of engineering skills relative to demand within the British Isles. Most major construction projects with significant British technical involvement are undertaken for overseas clients in developing countries, particularly in the Middle East and increasingly Latin America.

At present three consortia have formed to develop new nuclear power stations, which are essentially single-build projects at a handful of power station sites in the UK (see **Table 1**). There is a risk that these first-wave nuclear build projects are one-shot deals with no realistic prospect of repeat business elsewhere in the UK market. The large-scale recruitment of engineers needed for long-term energy security will only triggered by a second-wave of nuclear build.

REPLACING COAL WITH NUCLEAR

A second-wave nuclear renaissance would have a genuine beneficial impact on reducing Britain's carbon emissions. The Government explained in its analysis of Imperative Reasons of Overriding Public Interest (IROPI) for nuclear reactor construction, that the failure to take account of significant early deployability will increase the risk that the UK is locked into higher carbon emissions than would otherwise be necessary. In turn this will mean that meeting the Government's targets for very significant decarbonisation of the economy will become correspondingly more difficult and expensive.

The Government therefore believes that there is a significant public interest in nuclear sites being deployed as early as possible[20]. Assuming that gas and renewable generation continue to remain important in the UK electricity mix, a second-wave of nuclear build would essentially mean replacing coal capacity with nuclear capacity, increasing the share of nuclear electricity generation from the present level of 14% up to around 35–40% beyond 2030 as proposed by the Wicks Review.

The second-wave is crucial to reaching the UK's 2050 decarbonisation goals and implies a major future squeeze on the British engineering supply chain. From an engineering standpoint, firm commitment to a second-wave is highly desirable because constructors need a large fleet order book to invest in the right skills. Furthermore, the proposed electrification of the vehicle transport sector, and both domestic and commercial space heating, could probably only realistically be achieved economically with second-wave deployment of nuclear power as a significant component of the future generation mix.

IN SUMMARY

- The first-wave nuclear build will only marginally reduce low-carbon emissions in the UK as it replaces retiring nuclear stock.
- A committed second-wave new nuclear build beyond 2025 will help replace fossil fuel power generation and provide additional capacity to transition our transport sector and built environment to low-carbon options.

ELECTRIFYING OUR TRANSPORT SECTOR

Much of the automotive and rail industry has aligned behind electricity as the ground-transport fuel of the future. Substantial extra power generation is likely to be needed to deliver this in the long run, even discounting any demand reduction.

The Institution of Mechanical Engineers in its UK Energy 2050 report has estimated this requires current capacity to be doubled[21]. Decarbonisation implies profound industrial change from a 20th century oil-based economy to a 21st century electricity-based economy. Britain began to wean itself away from oil-fired electricity generation in the aftermath of the oil price shocks triggered by the 1970s OPEC oil crisis.

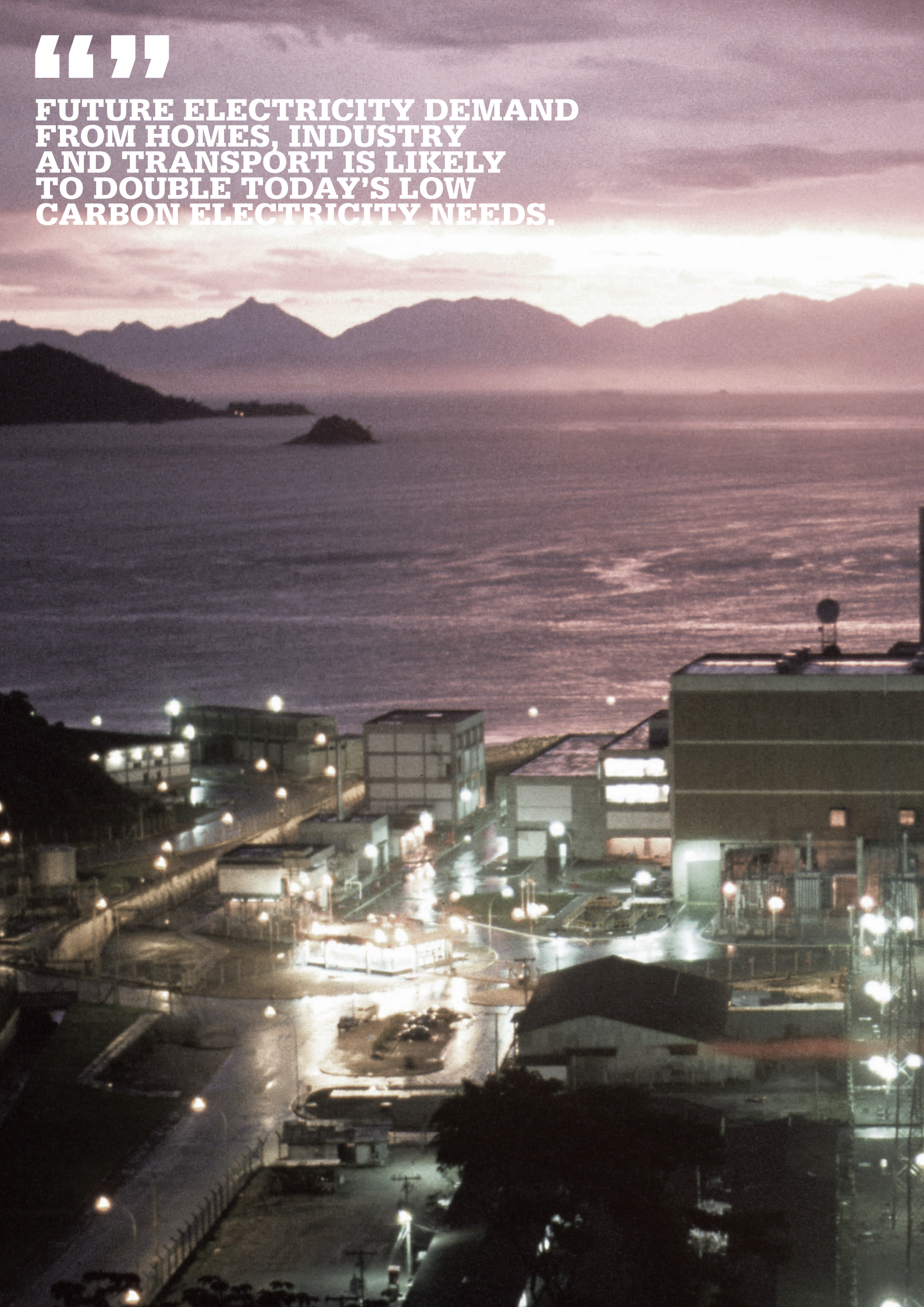
Today most oil is not consumed by oil-fired power stations but by the transport sector for road vehicles and the railway system, which together consumed 84% of Britain's 68.1 million tonnes of oil in 2008[22]. To date, very limited progress has been made switching consumer motor vehicles from internal combustion engines to electrical engines. Most cars remain petrol and diesel fuelled, albeit with better improvements in fuel efficiency. There has also been impressive technical progress at the higher end of the market, such as the Tesla electric car which has achieved similar sports performance to Porsche.

At present UK rail transport energy consumption is split roughly 50/50 between electricity and diesel. The UK lags behind most European countries with only a third of its rail network electrified (5,200km out of 15,800km).

The Conservative Green Paper, 'The Low Carbon Economy: Security, Stability and Green Growth' foresees a 21st century Britain radically different from today in which electricity, rather than oil, is the primary motive power source[23]. The August 2009 Wicks Review by the Prime Minister's Special Representative on International Energy Issues reached similar findings and to meet the demands it recommended that nuclear power should provide some 35–40% of Britain's electricity beyond 2030[24].

The political consensus is that deployment of electrical power will significantly expand from the home and workplace to encompass some or all of the transport sector, with substantial numbers of electric cars predicted by 2030. A new national recharging network would be needed enabling Britain to lead the world in replacing traditional cars with electric and plug-in hybrid vehicles.

As an indication of the magnitude of the task, the UK electricity industry generated the final energy equivalent of 29.4 million tonnes of oil in 2008, while transport consumed 57.3 million tonnes of oil equivalent. Allowing for energy efficiency, switching transportation completely to electrical power today would need an additional two-thirds electricity generation to replace oil use, on top of today's existing power station capacity[25]. Combined with increased electricity demand in other sectors, this is closer to a factor of two. Simply put, in the future, electrical energy will directly power homes, industry and the road and rail transport networks, possibly doubling today's low carbon electricity needs.



FUTURE ELECTRICITY DEMAND FROM HOMES, INDUSTRY AND TRANSPORT IS LIKELY TO DOUBLE TODAY'S LOW CARBON ELECTRICITY NEEDS.

WHY UTILITIES ARE INVESTING IN BRITAIN?

Three competing energy utility consortia are participating in the first-wave nuclear renaissance in the UK; A French dominated consortium comprising EDF Energy with Centrica (80%:20%); A German consortium comprising RWE with E.ON (50%:50%); And a consortium comprising Iberdrola (Spain)with GDF Suez (France-Belgium) and minority partner Scottish and Southern Energy (SSE) (37.5%:37.5%:25%). Together these three nuclear consortia are 85% foreign owned, with the London Stock Exchange listed FTSE 100 British companies Centrica and SSE making up just 15% of the overall shareholding.

During 2009 the consortia invested £500 million acquiring land for nuclear development in Britain, sending a strong signal of strategic intent[26]. However although Britain offers good opportunities for nuclear build, it is certainly not a simple energy market for foreign utilities to penetrate and work within.

It is important to appreciate that the strategic reasons for choosing to enter Britain's nuclear renaissance have as much to do with the domestic energy politics in their own home countries as they do with the relative commercial attractiveness of the UK. In other words, Britain's success in decarbonising its own energy infrastructure depends on the policies of other European governments.

This complicates, and could possibly compromise, British energy policy if we delay. Probably the two major threats to Britain's nuclear programme are constraints on state-backed capital financing of the French utility firm EDF and its reactor vendor Areva, and also possible reversal of domestic nuclear phase-out agreements in Germany, Belgium and Spain. For example, the Swedish energy utility Vattenfall nominated land at Sellafield for new nuclear build in March 2009 but subsequently announced a 12–18 month withdrawal from the UK nuclear energy market just three months later, apparently because Sweden was preparing to reverse its 1997 nuclear phase-out agreement. Reversal of the nuclear phase-out will allow Vattenfall to build new nuclear plants more easily in its home energy market in Sweden rather than abroad in the UK.

It is therefore, an important consideration that the UK needs to be seen to have attractive long-term investment potential. This potential will only be gained if companies see a Government committed to nuclear build for the foreseeable future.

THE ROLE OF ENGINEERS IN NUCLEAR BUILD

Building a nuclear power station involves a large multinational supply-chain network of civil, electrical and mechanical engineers. A typical reactor project would involve perhaps 1,000 trained engineers, 20% with specialist nuclear skills and 80% with wider infrastructure engineering experience.

The mix of engineering skills varies considerably during the six-year lifecycle of a reactor construction project. Mechanical engineers become deeply involved about mid-way through construction. The manufacturer's reactor design team, known as the Design Authority, employs a small team of highly qualified nuclear engineers and reactor physicists. The Design Authority supplies the construction team with a Build-to-Print generically licensed reactor design.

Energy utilities ideally prefer to buy lump-sum turnkey power stations as a finished product for a fixed price. In this case the reactor manufacturer (called the reactor vendor) and their construction partner organisation will undertake the complete construction and employ most of the workforce.

Civil engineers supervise the first two years of station construction as the reactor foundations and concrete structures are laid and erected. Once completed, mechanical engineers take-over supervising the reactor core installation and steam raising system on the reactor island during years three and four. Electrical and mechanical engineers also install a steam-driven electricity generation turbine dynamo on a turbine island separate from the main reactor system. The fifth year of construction involves a mix of electrical and mechanical engineers as the two island systems are fully integrated and a safety-critical reactor control and instrumentation (C&I) system is installed.

The reactor is finally tested, commissioned into operation and connected to the electricity grid during the fifth and sixth years of construction. A small number of specialist nuclear operators employed by the energy utility then take-over the day-to-day operation of the nuclear reactor and monitor its key safety systems. The Design Authority engineers will continue to be involved over the reactor's 60-year operating lifetime, advising on uranium fuel core loading, periodic maintenance outages, regulatory safety case reviews and occasional fault rectifications when aging problems are identified.

DEVELOPING THE RIGHT ENGINEERING TALENT

The Government launched the Nuclear Advanced Manufacturing Research Centre (NAMRC) at Sheffield in December 2009. NAMRC will be led by the University of Sheffield in partnership with the University of Manchester and Rolls-Royce as the lead industrial partner, with £25 million of seed funding from Government.

NAMRC will be located near a planned £75 million Rolls-Royce civil nuclear manufacturing facility, including £11 million of further Government funding, to manufacture, assemble and test components for new civil nuclear power plants[27]. NAMRC will focus on smaller specialised items and in helping UK companies to improve their quality standards so they can compete with existing overseas nuclear suppliers. These are important steps in the right direction, but alone they are not enough. The £36 million of annual nuclear engineering investment by Government is minimal compared with the multi-billion investment the Government is asking private sector energy utilities to make in decarbonising Britain.

Although any investment in manufacturing facilities is very much welcomed, there is a pressing need for broader-based civil, mechanical and electrical engineers familiar with the energy sector. Government could perhaps make a much greater impact on skills supply by offering incentives to students for all energy-related engineering courses at higher education establishments and Universities.

In a period of severe constraint on the public purse, a clear set of 'vital occupation' priorities for the well-being of the nation must be established, with the energy sector being one such priority occupation. In doing so, funding could be chanelled to a broader range of people with diverse engineering interests and backgrounds. This strategy would ensure the flow of freshly trained graduate engineers into the energy sector, however, incentives should be connected to them becoming registered professional engineers.

NUCLEAR DECOMMISSIONING BRAIN DRAIN

There is no risk of a skilled labour supply crunch for the initial development of new nuclear build in Britain. The consulting engineering supply chain is highly capable and eager to participate in nuclear build projects. This does not mean that Britain's nuclear labour market will remain unaffected by the first reactor orders. The likelihood is that there will be an immediate brain-drain of engineers with nuclear experience recruited away from the nuclear decommissioning market and other highly regulated industries.

This internal market shift may take place at two levels; at the market sector level as engineering firms switch from the Government's budget constrained decommissioning business to secure better long-term high-value new build contracts; and also at a personal level as nuclear engineers simply choose to leave their decommissioning employers to join exciting nuclear build companies.

It is a truism that professional engineers naturally prefer to build things rather than decommission them. The prospect of a brain drain is worrying because the Government's Nuclear Decommissioning Authority performs a critical mission for the UK, cleaning-up historic nuclear liabilities. Since its creation in 2005, the Nuclear Decommissioning Authority's capital expenditure with the engineering supply chain has increased, with business up 46% from £277 million in 2005/6[28] to £404 million in 2008/9[29]. Much of this expenditure has been on design and development of capital projects providing relevant experience for engineers who will be able to switch this capability over to the new nuclear build market.

This raises some difficult questions about whether the Nuclear Decommissioning Authority will continue to have good access to contractor skills for its safety-related nuclear waste treatment, encapsulation and storage programmes in the national interest. These programmes include the construction of a deep Geological Disposal Facility (GDF), possibly within this decade if a suitable volunteer site is identified soon by Government[30]. In this regard, the Government needs to set a firm deadline for communities to volunteer so that engagement processes and analysis work can begin. Such a disposal site for reactor spent fuel is viewed by many stakeholders as a key technical and ethical enabler for allowing new nuclear build to proceed. The future existence of an operating GDF formed an important component of the Government's 2009 'Draft Nuclear National Policy Statement for Nuclear Power Generation'[31]. The Government must ensure that this project is seen to be moving forward, is adequately funded and is able to retain the engineering expertise once the new-build programme starts to impact.

INTERNATIONAL COMPETITION

Modern nuclear construction projects are intrinsically multinational in character[32]. Britain's nuclear renaissance relies heavily on planned investment from French, German, Belgian and Spanish foreign energy utility firms. The three participating nuclear consortia are 85% foreign owned, with British companies making up just 15%. It would not be surprising if these multinational energy companies procured some or even the majority of their reactor engineering needs competitively from within the EC Single European Market supply chain.

British nuclear workers have a competitive advantage because they tend to be cheaper (they earn about 20–30% less than equivalent European nuclear staff)[33] and are operating within their domestic market which is always simpler and more efficient. From a business perspective it makes economic sense to utilise local resources first. The US reactor manufacturer Westinghouse even has an explicit 'We buy where we build' localisation policy for its reactor exports.

Following the liberalisation of Britain's electricity market in the 1990s, British utilities have slimmed down their workforce considerably. But this is not the same for the continental nuclear energy utility companies who still retain significant in-house nuclear engineering capability. Nuclear phase-outs in Germany, Belgium and Spain will mean that utilities have to find jobs for their own nuclear people first. To some extent this cultural mindset extends to the European supply chain as well, meaning that on balance a utility firm will prefer a previous partner they have successfully worked with before, who has a shared understanding of business culture, risk management and joint ways of doing business provided that the project costs are similar to UK firms.

This is an important cultural phenomenon and its impact on the selection of contractors for foreign-backed nuclear build projects in the UK should not be underestimated. The 1996 Posted Workers Directive allows companies to employ their own staff on projects in other EU states including Britain, as long as this is for a limited time and the company abides by local working conditions. When Finnish energy utility TVO selected Areva to construct the Olkiluoto-3 nuclear reactor in 2004, there was an expectation that Areva would sub-contract with the supply chain in Finland to the fullest and the main share of subcontractable work would be conducted by Finnish companies. In fact Areva subcontracted with firms mostly outside of Finland.

There may be substantial risks of revenue-drain away from the UK if reactor components can be pre-constructed and shipped from mainland Europe or networks of technical engineering teams can operate remotely from their home countries via the internet. But there are also some factors which count against the use of continental nuclear labour. Firstly, their professional salaries are higher. Secondly, it is expensive to second staff into a foreign country for any great length of time because the travel costs become too prohibitive. Thirdly, there are industrial relations aspects to consider: the 2009 Lindsey Oil Refinery strikes were triggered when refinery owner TOTAL awarded a construction project to an Italian rather than a British team of contractors. Industrial action spread to other energy industry construction sites throughout Britain, specifically at Sellafield.

For first-wave nuclear-build, continental energy utilities have a genuine choice of skilled suppliers in the UK and mainland Europe. The sales challenge for UK nuclear engineering firms is to show that they make the best and most flexible local partner for new nuclear builds undertaken by energy utility consortia. If the UK pursues a second-wave nuclear build then the risks to the UK supply chain are much lower, as the full technical capabilities of both sides of the continent will be needed to deliver the build programme successfully.

Since most components and resources can be sourced relatively easily from around the world, it is unlikely that the first-wave new-build will lead to a large-scale revival of the UK nuclear manufacturing sector. But with proposals taking shape in 40 nations for parallel new build programmes, a global supply bottleneck is likely to emerge. With investment in the UK manufacturing base, up to 80% of all the required items could be sourced locally[34]. A commitment to a future second-wave does open many possibilities for the UK to establish local capability against an ongoing demand. A second-wave would mean the biggest commercial nuclear-build programme ever undertaken in the UK and could act as a much needed resurgence to British manufacturing, an area in which the UK was once a global leader.

IN SUMMARY

- The nuclear build programme (home and abroad) offers the UK an ideal opportunity to create new manufacturing capacity.
- The UK must ensure it has the engineering talent available to build the first and second waves of nuclear power stations.
- The Government must establish a set of 'vital occupation' priorities for the nation. This must include engineers for our energy sector.

Finally, if the Government were to introduce loan guarantees as a confidence measure to the industry, it could create the environment for an 'Engineered in Britain' element to be added to any agreement. This encouragement, based on a 'We buy where we build' philosophy, would guarantee that a percentage of the employment and components needed would be sourced and produced in the UK. This would help stimulate new manufacturing capability, especially where there are known international bottlenecks in nuclear build production.

The UK has a recognised reputation for quality in nuclear safety and standards – indeed it could be seen as the 'Gold Standard'. For companies to work to such high specification of construction and quality requires them to set demanding standards. Once approved, UK manufacturing companies would be able to sell their products into a growing international nuclear market.

RECOMMENDATION TWO

For Government to show clear commitment to a second-wave nuclear new build programme beyond 2025. This phase is crucial if the UK wishes to transition its transport sector (namely road and rail) and the built environment towards electricity, and encourage the development of a reinvigorated UK manufacturing base, positioned to exploit the substantial nuclear new build markets emerging worldwide.

RECOMMENDATION THREE

For Government to identify 'vital occupations' needed for the nation's future low-carbon development with the nuclear power industry being one such occupation. Such nationally critical occupations should be financially incentivised, including course fee repayment, to bring in the necessary quantity and quality of talent to these professions. The Institution believes it essential that the UK develops skilled engineers and technicians required to build, maintain and ultimately decommission nuclear power stations. This is central to it maintaining the 'Gold Standard' reputation for quality and safety.

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