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UK Power

Capabilities for a low carbon future

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With an annual turnover of \$50 billion, the UK's power sector employs 230,000 people and has exports of more than \$6 billion per year to over 100 countries.

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The UK's power sector plays a leading role in the global development of generative capacity, and is at the heart of the massive international 'push for power'.

World electricity generation capacity is forecast to reach almost 34,000TWh by 2030, requiring an investment into new generative capacity of around 5,000GW.

This will require thousands of new-build renewable, nuclear and thermal installations. Once operational, the new power stations will need ongoing maintenance and repair, asset management and upgrading. Transmission and distributions networks must be constructed to supply the consumers of this new generative capacity.

The skills, experience and expertise of the UK-based power sector and its supply chain are geared to meeting this demand.



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Introduction

The UK power sector and its supply chain are perfectly positioned to support global investment in new generative capacity, new sources of energy and the transmission and distribution networks to link these new power sources with consumers.

UK power companies already play a major role in the global development and management of power and generative capacity. The UK's power sector has an annual turnover of \$50 billion, of which \$6 billion a year is in exported goods and services to over 100 countries.

Global generative capacity is forecast to grow to 34,000TWh by 2030. To achieve this target, utilities and governments must invest in creating new generative capacity of more than 5,000GW over the next two decades. This huge increase in capacity will require thousands of new-build renewable nuclear and thermal installations. The UK is perfectly placed to meet this demand; its firms have built thermal power stations for over a century; nuclear power plants for more than 50 years; and its renewable power generation sector is world leading.

In parallel with the creation of new power plants, there is an ongoing need for maintenance, repair and outage (MRO), plus upgrade and decommissioning of existing generative capacity. UK firms, through the extended power sector supply chain, have pioneered new technologies that enable major works on power plants to take place safely and without interrupting supply. Also, the UK supply chain includes many original equipment manufacturers (OEMs) of leading power equipment.

Pioneering carbon capture and storage technologies, including the development of novel cleaner fuels, are being developed by UK researchers in academia, utilities and private firms. These technologies are being created and tested to tackle the challenges of scrubbing carbon dioxide from thermal power plant and other large point source emissions, and evaluating the health and safety options of long-term underground storage.

Transmission and distribution networks must be created, maintained and upgraded to ensure energy consumers' uninterrupted energy needs are met. The emergence of potentially intermittent renewable energy sources, such as wind, solar, wave and tidal, as major contributors to power grids has led to the creation of smart network and demand management technologies to ensure reliability of supply.

Many UK companies have significant experience of asset managing, maintaining, upgrading and decommissioning power plants of various ages and designs, and this expertise is already widely exported. As the birthplace of civil nuclear power, and with many plants undergoing planned closure, the UK's nuclear decommissioning expertise is exceptional.

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The Crown Estate, which administers the UK seabed, has awarded ten contracts to companies to develop up to 120 MW of wave and tidal power in Scotland.

Research, education and training are a vital component of the UK power sector. There are over a dozen internationally renowned UK universities with major research programmes into power and energy. The Energy Technology Institute (ETI) provides a vital link between research and business, and is forecast to invest \$2 billion into energy and power research over the ten years to 2017.

Many global utility and engineering groups have chosen to base their research and development facilities in the UK, where they can access a large pool of expertise and talent. The training and education sector features some of the world's most advanced training facilities, such as the use of state-of-the-art simulators for training new power plant operators.

UK Capability

UK energy companies are forecast to generate revenues of \$300 billion by 2030, employing one million workers.

The UK can offer world-class solutions across the entire power supply chain. UK capabilities cover renewable, nuclear and thermal power generation, transmission and distribution. The UK is ideally positioned to help utilities and governments meet the forecast 50 per cent increase in global energy demand by 2030.

cleaner | greener | future-focused



Many of the world's largest energy companies participate in the UK-based Energy Technology Institute, which is forecast to allocate \$2 billion into research over the ten years to 2017".

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Renewable energy

The British Isles have wind, wave and tidal stream natural resources in abundance. This has led to the UK becoming a global centre for the development of world leading renewable power generation capabilities.

The UK is the windiest place in Europe and around its coastline has the world's best tidal and wave resources for the generation of renewable energy. This abundance of natural resources has resulted in the UK becoming a global centre of excellence in the development and application of renewable power generation technologies. By 2050, investment into the existing and emerging renewable capabilities of the supply chain of just six low-carbon technologies is expected to create 175,000 jobs and generate \$40 billion a year. This will cover cutting-edge research across sectors such as onshore, marine, landfill gas and biomass, fuel cells, geothermal energy and hydroelectric power.

The UK's offshore engineering and transmission expertise is internationally recognised as leading the world in offshore and subsea engineering, transmission and distribution. This expertise is based on the development of the UK's world-class oil and gas industry. Now, the offshore, marine and subsea engineering expertise of UK-based companies is increasingly being applied to offshore wind and wave power generation. In 2009, the UK became the world's biggest offshore wind power generator and in 2010 reached the milestone capacity of 1.2GW, the first wind energy market in the world to do so.

Harnessing the power of abundant natural resources

Onshore and offshore wind power coupled with wave and tidal stream energy

UK companies are world leaders in the implementation of existing wind and marine power generation technologies. They are also at the forefront of research, development and exploitation of technology innovation in these sectors. The UK's first onshore wind farm was built in 1991, marking the beginning of a new era of renewable power generation and technological development.



The UK is forecast to capture just under a quarter of the global marine energy market, generating up to 68,000 jobs and \$121 billion by 2050 – Carbon Trust Analysis



The UK is the windiest place in Europe, with the largest single market and installed capacity of offshore wind energy, currently at 1.34GW. It also has the world's best tidal and wave resources for the generation of renewable energy, and marine energy is forecast to power 15 million UK homes by 2050”.

Less than a decade later, the UK's first offshore wind farm was commissioned in 2000. The UK's offshore wind sector has since become a world leader in offshore wind power generation technology. Moreover, UK-based projects now account for around a quarter of all wave projects and tidal energy developments worldwide.

One reason for the UK's pre-eminence in the renewables sector is the transfer of knowledge and technology from the UK's North Sea oil and gas industry. Having developed innovative technology to extract oil and gas from the challenging environment of the North Sea, UK-based engineering contractors are now adapting these technologies and bringing further. This is leading to the development of near-shore, onshore and far-offshore wind infrastructure, other marine renewables and the transmission and distribution networks connecting consumers with energy sources.

Pipeline upgrade releases additional power

Hydropower upgrade delivers 40 per cent more power from available resources

UK engineering company Mott MacDonald is leading design of a US\$700 million project to harness energy from water before it is released for irrigation. Careful attention to the length, size and geometry of pipelines connecting to a new hydropower station at Tarbela Dam in Pakistan is enabling 40 per cent more electricity to be generated than originally envisaged.

In 1992, a feasibility study concluded that 960MW could be generated. Mott MacDonald has found ways to improve efficiency, which means 1.32GW of additional generating capacity can be installed. The new plant will increase maximum power output from Tarbela Dam by 40 per cent – from 3.48GW to 4.8GW. Tarbela currently supplies 20 per cent of Pakistan's electricity.

When the new power house begins production in 2016 its contribution will grow to 28 per cent. Tarbela Dam lies on the River Indus 50km from Lahore. It was completed in 1974 to hold back peak spring and summertime water flow. It is released at a constant rate throughout the year via five tunnelled pipelines.

With a hydraulic head of 130 million, there is huge energy potential in the release of irrigation water and generating capacity is already installed on three of the tunnels.

Mott MacDonald is bringing the fourth tunnel into play, diverting water from the existing outlet to a new powerhouse. This has been optimally sited to minimise energy losses within the pipeline, delivering maximum power output.

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Generating a stream of world-class renewable technologies

UK capabilities in hydro, photovoltaics, fuel cells, geothermal and biomass

The UK hydro industry is at the forefront of the hydropower industry globally and can provide high quality products and services covering all aspects, types and sizes of hydropower schemes. The industry offers consultancy expertise at every stage of any project, and UK consultancies have developed the expertise to undertake the comprehensive environmental and social studies required during the planning of hydropower projects. This expertise augments the UK's engineering and technical competencies, which are in turn supported by manufacturing companies that provide exceptional hydro turbines and other

hydro-mechanical equipment. UK firms are currently operating in Africa and Asia in developing new-build hydropower projects.

The UK solar power market is worth \$1.6 billion a year and UK firms and universities number among the world's leading centres of research into photovoltaics (PV). Key research capabilities include organic photovoltaic (OPV) technology and dye sensitised solar cells research to create extremely low cost PV solar panels. The UK is also home to leading firms delivering the production, installation and integration of PV products.

There is also growing UK capability in fuel cells, where a number of world class companies produce materials, components and complete systems. The UK's particular strengths lie in solid oxide

fuel cells (SOFC) and proton exchange membrane fuel cells (PEMFC), extending from materials and components through to full systems. In the power generation sector, these systems can provide power for a variety of applications.

The geothermal energy and ground source heat pump supply chains are well developed in the UK. Capabilities range from the drilling engineering expertise to tap deep geothermal sources to the manufacture and installation of domestic heat pumps. Energy from waste is a core element of the UK Biomass Strategy which in turn is driving the development of capabilities that will nearly treble the amount of municipal waste turned into energy. Combined heat and power (CHP) is the favoured solution and UK-based firms offer CHP engineering, design and manufacturing solutions at every stage of the supply chain.

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Wave energy solution at large-scale prototype stage

Floating, deep water wave energy converters

Offshore Wave Energy Ltd (OWEL) has developed a wave energy converter that can operate in deep water. The UK-based business leads a consortium, which has been awarded a \$4 million grant from the UK's Technology Strategy Board to develop a large-scale working model to test the commercial feasibility of the technology in the open sea.

The first 42 million demonstrator under construction will be rated at 500kw and will be tested at the Wave Hub facility off the South West coast of the UK. A second wave energy converter rated at 1MW will be deployed in the open sea and be used to test the technology's commercial viability. OWEL's wave energy converter uses patented technology that traps and compresses the air between wave peaks. The compressed air is fed to a turbine, which in turns drives a generator to produce electricity.

The theory behind the design has been tested by numerical modelling, in the laboratory and at small scale at the UK's National Renewable Energy Centre (NAREC).

The consortium partners include the technical consultants IT Power, the National Physical Laboratory, the University of Plymouth, plus consulting engineers Gifford and A&P Falmouth. Det Norske Veritas will provide design certification.

Nuclear energy

The world's first commercially operated nuclear power station went live in the UK over 50 years ago. Since then, UK firms have safely built, operated, maintained, upgraded and decommissioned civil nuclear power facilities in the UK and throughout the world.

The UK is the birthplace of civil nuclear power, and is at the forefront of a nuclear renaissance that could see up to 16GW of new generative capacity built in the UK before 2025. Because the UK is one of the few energy markets that has licensed several different reactor technologies, UK companies can deliver comprehensive solutions across most major nuclear power technology platforms throughout the fuel cycle. This includes every aspect of new build – from design and engineering, project management and safety, through civil, mechanical and electrical engineering, to final commissioning.

With the UK being such an early adopter of nuclear power, UK firms have great experience on building and maintaining nuclear facilities, often over several decades. As nuclear stations in the UK have aged, the UK industry has developed in-depth capabilities to upgrade and safely extend their operational life. And UK companies are at the forefront of creating and implementing decommissioning strategies. These are being safely and successfully applied to the shutdown of numerous nuclear facilities.



In addition to its technical and consultancy skills, the UK has a strong nuclear supply chain. UK-based firms manufacture and supply a wide range of sophisticated products and systems, including the balance of plant, safety products and monitoring and control systems. Expert and nuclear-focused service providers include software developers, legal, accountancy and

insurance providers, while the UK's financial sector offers unrivalled access to the world's financial markets and energy investors.

Ensuring the highest standards of safety is the UK's regulatory framework, which is one of the toughest in the world and internationally recognised as a global benchmark.

New build, operation, maintenance and upgrades

Latest generation nuclear technologies for new and existing plants

UK companies can offer new-build capabilities from turn-key engineering, procurement and construction (EPC) projects to providing a range of specialist sub-contracting services. The expertise available spans all the disciplines required to build new nuclear power plants – from design, civil engineering, mechanical and electrical engineering to safety and control systems, testing, health physics and nuclear plant commissioning. The UK hosts numerous original equipment manufacturers (OEMs), and the extensive supply chain has developed a world-leading high-tech manufacturing capability that supplies new-build nuclear programmes globally.

Operation and maintenance of nuclear power plants has been taking place in the UK for over fifty years, resulting in a highly developed maintenance, repair and overhaul (MRO) infrastructure. UK-based firms can offer embedded maintenance teams and expert in-service inspection (ISI), non-destructive testing (NDT) and monitoring services, including essential safety and health physics for plant operators.

To maximise the lifetime value of nuclear assets and improve operational efficiency and safety, nuclear power plants undergo ongoing upgrades and improvements using the latest technologies. Often upgrades must be implemented without interrupting

supply, and UK companies have become expert at such MRO and upgrade projects. UK upgrading and retrofitting expertise spans both the nuclear island and the balance of plant, offering leading edge, high-efficiency turbine and boiler solutions.

Waste management, decommissioning and disposal

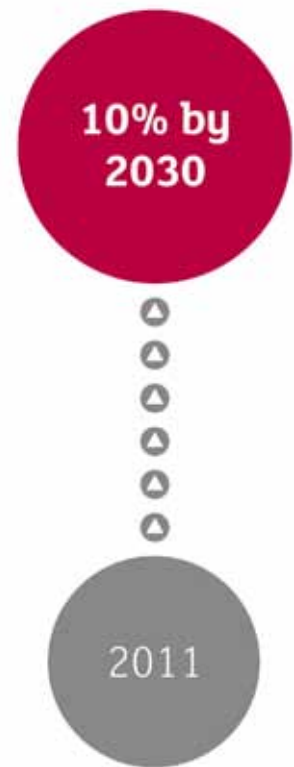
UK capabilities in managing the nuclear power fuel cycle

The maturity of the UK nuclear power stations has led to the creation and growth of a service sector and supply chain expert at safely managing one of the most sensitive aspects of the nuclear cycle – waste management, decommissioning and disposal. UK companies are already engaged with decommissioning the UK's first generation Magnox power stations; the UK Nuclear Decommissioning Authority's 2009-10 budget for such work was over \$4.54 billion. UK firms actively apply their unrivalled expertise throughout Western and Eastern Europe, and further afield in countries including the USA and Russia.

UK decommissioning capabilities include front-end planning and engineering consultancy, radiation mapping, plus nuclear waste characterisation and measurement services. UK contractors can offer plant decommissioning, decontamination and dismantling services. The supply chain includes nuclear materials transportation expertise, waste containment and radiological protection products and safety

management. UK companies also offer leading capabilities in post-decommissioning waste storage, including deep geological storage, and environmental remediation.

Nuclear industry increase



By 2030, the global nuclear industry is forecast to increase its capacity by 10%, representing over \$300 billion of investment over the next two decades.

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The UK nuclear supply chain offers over 50 years of civil nuclear experience and 80,000 expert and highly skilled workers, generating exports worth \$1.14 billion”.

Forging new global supply relationships

Exporting bespoke large-scale castings and forgings

Sheffield Forgemasters International Ltd (SFIL) is a world leader in the provision of high quality, heavy forged and cast steel products. It produces some of the largest bespoke engineered products in the world, with a capacity for castings of up to 350 tonnes and forgings of up to 175 tonnes.

In partnership with Curtiss-Wright EMD, SFIL developed a manufacturing process for cast stainless steel pump casings for the Westinghouse AP1000TM reactor. On the back of this success it was subsequently commissioned, by Curtis-Wright Flow Control Company on behalf of Westinghouse, to produce 18 pump casings for the new Chinese AP1000 plants at Sanmen and Haiya.

The 16 tonne reactor coolant pump castings are manufactured at the company's UK foundry using modern casting simulation and 'methoding' techniques to create high integrity finished structures. Since the pump casings are structurally integral to the reactor and safety critical, the project is highly specific and requires technically demanding manufacturing methods. For example, detailed metallurgical specifications must be met to achieve optimum material strength characteristics.

In addition to the four Chinese AP1000s, Westinghouse has also signed three contracts to build six AP1000 nuclear power plants in the USA, with a number of possible further orders in prospect. SFIL has already been commissioned to produce 16 of the casings for the first US plants.





Extending the life of existing nuclear power stations

Effective asset management of nuclear facilities

Ontario Power Generation (OPG) is involved in the early stages of planning a multibillion dollar project to refurbish and extend the life of its existing Darlington nuclear power station. This will involve the management of several types of projects over a period of over ten years.

UK-based Atkins was commissioned to provide project planning and control services through the project development phase over an initial three-year duration. This includes a review of the project scope, processes, budget and schedule, plus a number of independent risk assessments.

The study to date has included review of the programme management organisation, development of a flexible contracting strategy, and an estimate to support the current request for further funding. Also achieved has been a review of the relevant project governance processes and interviews with key members of the project. The review was carried out in stages and identified several areas in which further development was required to maximise the project's success.

Thermal generation

UK firms are active at every stage of the thermal power generation supply chain. The UK's thermal power expertise spans over one and a quarter centuries, with the first public steam-driven power station coming on line in London in 1882.

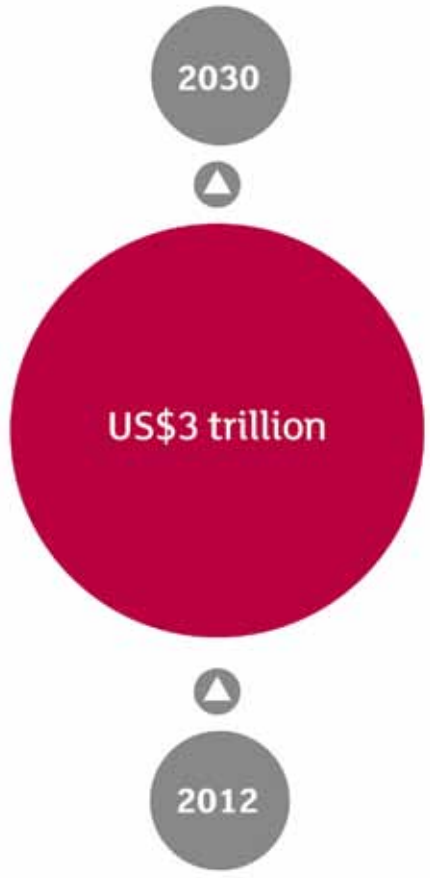
Since then, the UK has continued to host many of the world's leading original equipment manufacturers (OEMs) of boilers, steam turbines, gas turbines, generators and associated equipment and services.

The UK is the birthplace of the thermal power generation sector. And UK firms continue to be at the forefront of developing thermal power generation technologies. They also have unparalleled expertise in operation, upgrading and asset management. In recent years, UK-based companies have developed innovative carbon abatement technologies, incorporating carbon capture and storage (CCS) solutions and cleaner burning fuels into new and existing generative capacity and other major point sources of carbon dioxide emissions.

UK original equipment manufacturers and engineering firms offer products and services throughout the entire thermal power supply chain. Engineering, procurement and construction (EPC) companies can provide complete power station projects, with manufacturing companies making boilers, turbines, diesel engines and a huge range of associated equipment.

Supporting the sector are UK service companies that provide asset management and improvement, emission control systems, noise control and effluent treatment, all designed to meet the most demanding regulatory regimes.

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Global investment in thermal power generating capacity between now and 2030 is expected to be around US\$3 trillion



Testing carbon capture and storage solutions

Proving innovative, post-combustion carbon capture (PCCC) solutions

UK-headquartered Rosoman Power Systems, in partnership with SSE and Vattenfall, is working with the Swedish government to undertake a two-year post-combustion carbon capture test project at the SSE 2000MWe coal-fired power plant at Ferrybridge in the UK. The US\$33.6 million project focuses on the construction and demonstration of Europe's largest post-combustion CO₂ capture plant – a 15Mwth slipstream equivalent to 100 tonnes per day of CO₂ captured.

The process takes the flue gases from the power plant and passes them through a scrubbing process in which the CO₂ is absorbed into a solvent and removed from the flue gas stream. This CO₂ rich solvent is then pumped into a regeneration column where it is heated and the solvent releases the absorbed CO₂. The released CO₂ is then ready for drying and compression before transportation. The compressed CO₂ can then be reutilized for Enhanced Oil Recovery (EOR) or other process options some of which are currently

under development. It can also be taken to permanent storage in depleted oil and gas wells or deep saline aquifers.

During the two-year testing phase, the demonstration plant will typically operate in line with the power station. Extended operational testing will provide valuable insights into the validation of long-term phenomena. In addition to the industrial research and development focus, university researchers will also participate in the project to gain operational experience.



UK thermal power supply chain companies have developed supercritical steam turbine and boiler technologies that cut CO₂ emissions by up to 30%”.



Innovation and expertise in thermal power generation

From EPC to OEM: the UK's thermal power capabilities are broad and deep

The UK is home to companies that can offer complete new build engineering, procurement and construction (EPC) turn-key solutions. UK original equipment manufacturers (OEMs) are at the leading edge of power equipment design and innovation, providing power generation equipment that is exported worldwide. UK-based companies offer design, project management and manufacturing solutions for oil, gas, coal and biomass thermal power plants. A feature of UK expertise is its packaged power generation capabilities, including cogeneration combining heat and power, and tri-generation, or 'trigen', featuring power, heating and cooling. Trigen technologies are increasingly adopted in standby and emergency power generation environments.

UK-based consortia of utility and supply chain organisations are developing leading pre- and post-

combustion carbon capture and storage technologies. Several key pre- and post-combustion capture solutions are being tested at both custom-built test facilities and fully operational on-stream power stations. These include the development of cleaner burners using clean combustion fuels. Carbon storage solutions are being developed that are using the UK's depleted North Sea oil and gas fields as a proving ground. Processing technologies are under development to turn the carbon dioxide waste stream into raw materials for other industrial processes, such as producing decarbonised hydrogen.

Exploiting and enhancing power generation assets

Upgrading and extending the life of existing thermal power plants

With over a century and a quarter of thermal power generation history, the UK has a highly developed supply chain that is expert at upgrading, re-engineering, servicing and maintaining power generation facilities.

UK companies have both the expertise and the infrastructure to offer complete maintenance, repair and outage (MRO) programmes to maximise the safe extension of service life and improvements in efficiency. UK firms also have specific expertise in retrofitting for carbon abatement and efficiency improvements, and offer innovative carbon capture solutions.

The UK sector has assisted utility and energy companies to adapt to new ways of working, enabling more flexible operation with less downtime and lower emissions. The supply chain features companies with advanced monitoring and metering technology that is used for preventative maintenance programmes and to achieve valuable efficiency gains during operation.

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Thermal power using novel fuels

Thermal power generation using biofuels: bagasse in Mauritius

UK engineering firm Atkins was tasked by Sumitomo Mitsui Banking Corporation with developing an innovative new thermal power plant in Mauritius. The power station, developed by Compagnie Thermique de Belle Vue, has a nominal electrical capacity of 70MW and supplies process steam to the adjacent sugar mill during the sugar processing season.

An innovative feature of this power station is the fuel that is used during the sugar cane harvesting season: bagasse. This is the fibrous by-product arising from the pressing of sugar cane to release sugar juice. When bagasse is not available, imported coal is the primary fuel. Consequently, as bagasse is the only indigenous fuel on the island, there is every incentive to optimise its use, both on economic and environmental grounds.

The services provided by Atkins in support of the plant development included a wide range of financial advisory and technical services, drawing upon the extensive skills base held by the company's thermal generation group.

Cleaner burning of traditional fuels

Creating a consortium developing clean combustion technologies

Oxyfuel technologies are being developed in the UK as part of the rapidly evolving area of carbon capture and storage (CCS). The Oxyfuel process burns coal with nearly pure oxygen, resulting in an exhaust gas that is mostly water vapour and carbon dioxide (CO_2). Because of the high density of the waste CO_2 , it can be easily liquefied and transported.

In July 2012, UK-headquartered Doosan Power Systems opened its Clean Combustion Test Facility (CCTF), currently the largest of its type in the world, to demonstrate its oxyfuel combustion system.

To implement the project, Doosan Power Systems has created a unique UK industry and research consortium that includes prime sponsor SSE, sponsors EDF Energy, E.ON, Drax Power, Vattenfall, Dong Energy, Scottish Power, Air Products and UK Coal. Academic partners include Imperial College London and the University of Nottingham. The UK Government partner is the Department of Energy and Climate Change (DECC). The consortium's objective was to test oxyfuel technology and demonstrate that it can be used in large-scale utility power plants.

Using its proprietary full-scale 40MW OxyCoal burner technology, Doosan Power Systems has successfully shown that safe and stable operation is achieved across a wide operational envelope. Now fully tested, this technology is available for new build and retrofitting into large scale power plant.

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Transmission and distribution

UK companies have created a transmission, distribution and storage network to service one of the most liberalised, demanding and sophisticated energy markets in the world. This expertise is exported to over 100 countries worldwide.

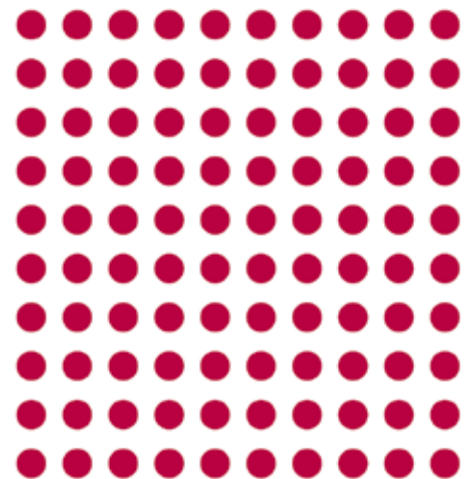
The UK transmission and distribution sector undertakes significant and ongoing research and application development into transmission and distribution networks. UK firms have created multiple technology innovations that have transformed distribution infrastructure. Sensor technologies and smart metering can track distribution network performance in real time. UK universities and companies are conducting world-leading research into smart grids and smart energy networks that can optimise and integrate power demand and supply management from multiple and potentially intermittent generation sources, maximising efficiency and reducing carbon emissions. Innovative safety technology improves leak detection for gas and businesses, reducing costs and improving efficiency.

UK companies have pioneered smart metering of energy supply and will be responsible for its roll-out to 26 million UK energy customers by 2020, replacing an estimated 53 million gas and electricity meters. Latest generation smart meters optimise consumer power consumption, maximise power utilisation efficiency,

and reduce costs and carbon emissions. Regulatory and technical expertise developed during the privatisation of the UK's energy market has been applied and are used internationally as a template for utility sector change.

Safety is a key feature of the UK's transmission and distribution network expertise. High gas distribution, sensor and gas compression system technology and distribution networks developed by UK companies are exported worldwide. Smart grid and active network management technologies for electrical power distribution are being pioneered at UK universities. UK firms manufacture and export core high-voltage direct current (HVDC), power electronics and switchgear technologies globally.

In response to tough environmental regulatory regimes, UK firms have invested in developing advanced transmission and distribution solutions. This includes pipeline materials and infrastructure for gas pipelines and electricity transmission cables that minimise embodied energy and energy use in operation.



The UK's leading transmission and distribution capabilities are exported to over 100 countries.

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Creating consortia that maintain national power networks

Underpinning the National Grid Central Electricity Alliance

UK-based Atkins supplies engineers to the UK's National Grid Alliance contract across a range of disciplines. National Grid owns and maintains the high-voltage electricity transmission system (275kV & 400kV) in England and Wales, together with operating the system across Great Britain, balancing supply with demand on a minute by minute basis.

National Grid established a new procurement initiative for delivery of their capital plan for the next regulatory period 2007-12. This initiative is based on Alliance contracts with consortia partners worth up to £1 billion over five years, to upgrade and develop the electricity transmission network across England and Wales. This is the largest ever Alliance contract for National Grid

and represents a significant part of National Grid's planned investment to maintain safe and secure supplies of energy to the UK.

These collaborative contracts will support planned work to connect new infrastructure, such as wind farms and other new generation plants, and replacement of existing assets, to ensure the continued safe and reliable operation of the high voltage electricity network. In response to this initiative, Atkins established consortia with an equipment supplier and construction company which was successful in securing an Alliance partnership with National Grid for delivery of the capital plan through the Central region of England and Wales.

The Alliance is now responsible for the delivery of National Grid's capital expenditure for all substation work and new connections to the system within that area. Individual projects typically being in the range of £5 million to £50 million. The Alliance works as 'one team' delivering the projects from feasibility through to commissioning, with a strong emphasis on the highest standards of Safety, Health, Environment, Security and Quality (SHESQ).

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Security of supply, safety, reliability and performance

Unrivalled expertise developing power transmission and distribution networks

The UK's energy transmission and distribution capabilities offer premium equipment and components alongside expert engineering, procurement, construction and management services.

UK firms have developed transmission capabilities to build overhead, underground and subsea power distribution networks in all

environments. UK subsea transmission and distribution expertise is world-leading, having been developed in the harsh conditions of the North Sea for the oil and gas sector, and is now being applied to the transmission networks of off-shore wind farms.

UK companies have also pioneered partnership, alliances and client management and service practices that are being adopted worldwide. UK-based contractors have established the practice of embedding dedicated engineering teams at client locations to reduce risk

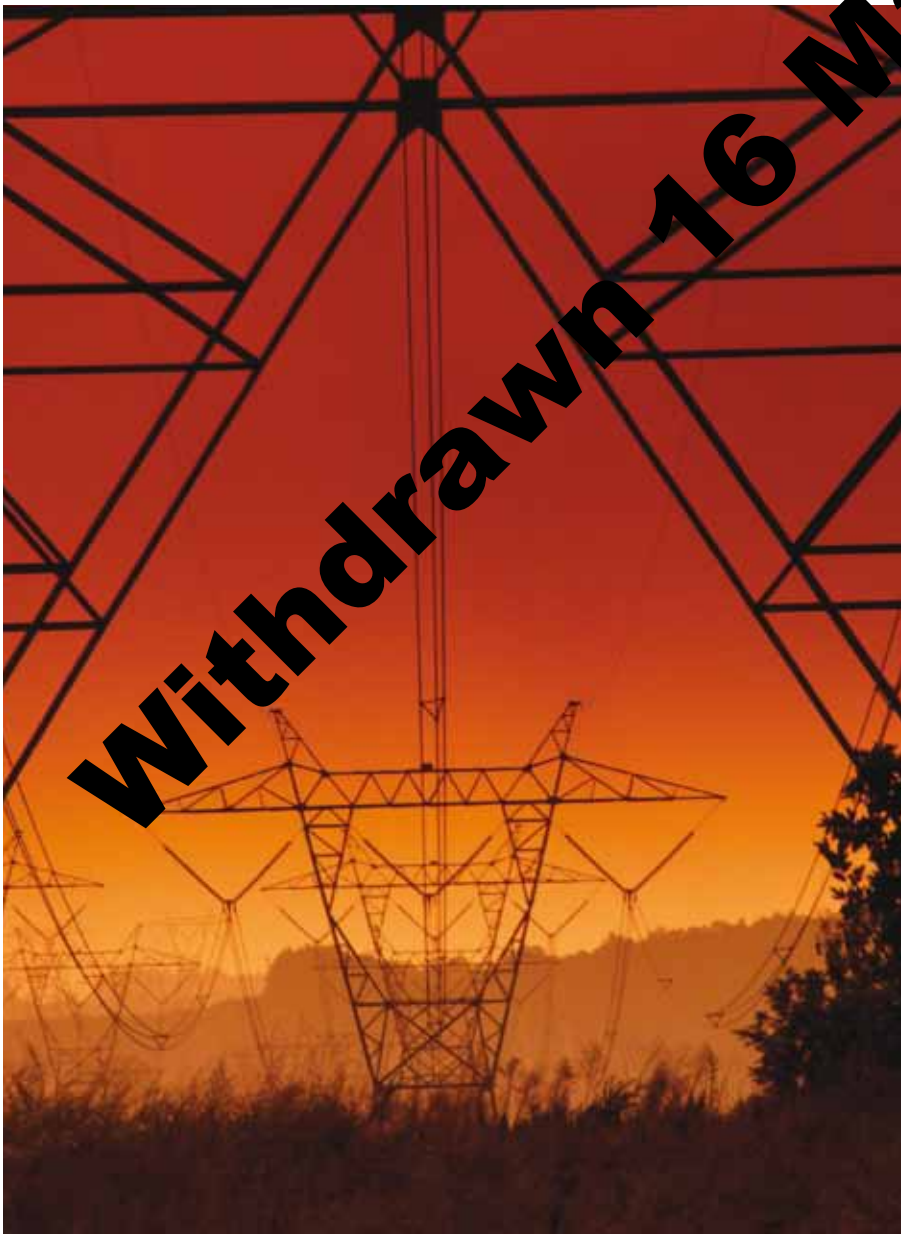
and increase energy supply security. And new methods developed in the UK of working in strategic alliance networks have revolutionised how the supply chain services and respond to the energy sector's needs.

Component and equipment solutions

Production and manufacturing expertise supporting 21st Century networks

The UK hosts original equipment manufacturers (OEM) of a huge variety of transmission and distribution products and equipment. High-value manufacturers create complex, heavy duty electrical equipment, including switchgear, transformers, relays and circuit breakers, which are exported to energy equipment markets globally. UK-based world-leading research has developed innovative long-distance electrical power transmission technologies that incorporate low-cost capital equipment with high levels of transmission efficiency. The UK supply chain also supports the maintenance, operation and upgrading of existing transmission and distribution networks, with UK companies specialising in providing ongoing maintenance, repair and outage (MRO) contracts.

A major feature of the UK transmission and distribution supply chain is the huge range of high-value, high-tech products and services available. Specialist goods and services include monitoring equipment, smart meters, sensors and safety equipment. UK-developed software solutions are used in power control and management centres worldwide, and UK expertise in regulatory compliance is internationally recognised and adopted.





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Improving network reliability with latest generation power distribution

Automation solutions to improve network efficiency and reliability

UK-based Lucy Switchgear has over the past six years been implementing automated medium voltage electrification network solutions for the Electricity Company of Ghana (ECG). The automation programmes are bringing multiple benefits to the national utility company, by helping: reduce electricity revenue losses; improve overall efficiency; minimise customer outages and reduce operational and maintenance costs.

The first phase of automating radial feeders across the rural areas and upgrading the underground network in the capital, Accra, was finished in 2005. Since then a further sixteen

schemes have been completed or are in progress. Future programmes will include the automation of 54 sites across Ghana's second city, Kumasi.

The distances involved and the sometimes difficult terrain has made the repair and restoration times long, resulting in inconvenience for the customers and lost revenue for ECG. But this automated electrification scheme has paid for itself very quickly. In addition, the importance of reliable electricity supplies for industrial customers is essential to maintain the country's economic performance and foster future growth.

Each project encompassed the design, equipment manufacture and delivery of the equipment to Ghana from the UK where Lucy Switchgear project teams managed the turnkey solutions locally to ensure that the programmes' objectives were met. Representatives from ECG attend an intensive training programme in the UK to gain a thorough understanding of the systems employed in these projects, enabling them to efficiently run and maintain the schemes once commissioned.

Asset management

Management expertise from UK-based companies is respected and sought out worldwide to enable organisations to maximise the return from managed power assets.

As power infrastructure ages, the challenges of generating optimal returns requires expert solutions, which the UK is perfectly placed to provide.

At every stage of the power asset management lifecycle, UK companies can offer expert services, so that owners may optimise the returns on their energy assets. From offering inspection programmes and condition assessment through to upgrading, refurbishment and replacement planning, UK firms have the experience and skills necessary to optimise performance.

Regulated assets require a focus on cost control and efficiency-based asset management strategies, and the scope for diversification and regulatory management can be limited. The return from generation assets can be enhanced by developing and applying production and trading optimisation strategies. The UK's management and technical consultants, as well as technical trainers, have developed a strong position in providing operational advice and support to asset managers in generation and network businesses.

Metering strategies have a huge role to play in asset management and the UK has been at the forefront of metering technology for decades. UK-based firms have established considerable expertise in smart metering and load control devices. These are now being applied worldwide in applications in which they are helping utilities to reduce the cost of meter reads, increase accuracy and cash collection rates, and provide improved services to their customers.



The UK roll-out of smart meters is a national project that will replace around **53 million** gas and electricity meters.



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Managing live assets in real time

Repair of power line assets without interrupting supply

Johannesburg City Power brought in UK engineering firm Mott MacDonald's local power business Merz and McLellan to provide design and engineering support for the complete replacement of a damaged pylon while the 88kV power lines it carried were still live.

Replacement of this asset was required after a car crashed through the base of a steel lattice pylon in south Johannesburg. Adjacent pylons' conductors held the damaged structure in position and power supply to the adjacent suburbs was unbroken.

The challenge was to replace the damaged pylon without an outage. This included checking the strength of adjacent pylons for the additional loads that would be temporarily applied during the replacement operation, specification for the replacement tower, new insulators and fittings, and managing public and worker safety.

The replacement was performed by transferring the energised lines from the damaged pylon to two robotic arms, mounted on mobile cranes. Using the arms, the lines were then moved apart,

creating enough space to demount the existing pylon and erect a new steel pole structure. The whole operation on site was completed in one day following three months of planning and engineering work.

Much of the transmission network is 60-80 years old and extensive refurbishment and replacement of pylons will be required in coming years. 'Live line' work is expected to become increasingly common as power companies seek to upgrade their networks without disrupting supply.



UK network operators have put in place sophisticated systems for tracking faults and determining their cause, duration and number of customers affected”.



Planning, procurement and operations

Optimal returns from fit-for-purpose energy asset investments

Expert asset management from experienced UK companies at the inception of a new energy project can result in optimal performance from the outset.

UK innovation in performance-based regulation (PBR) have led to the development of new competencies in assessing and maximising network service performance. UK firms are helping new and established utility networks around the world with the adoption of PBR, ensuring they balance their cost reduction requirements with maintaining and improving network service performance.

Operational efficiency is a key element of energy asset management. It can be addressed through strategic investment in equipment and systems, as well as by applying appropriate operating practices.

UK firms have developed operating strategies that range from flexible rostering and multi-tasking to enhanced training for network and plant operators. These strategies have been adopted worldwide by established and new utility grids.

Condition assessment

Maximising the performance of new and aging energy assets

Many new build energy and utility networks are being created in emerging economies, and UK companies are playing their part to ensure these incorporate the latest asset management best practice from the outset.

At the same time, established utilities are running aging plants with equipment that is no longer able to perform optimally, but does not warrant replacement. UK firms are experienced in managing aging power assets and completing the highly complex risk/benefit calculations to determine at which point an asset should be replaced.

For utility operators to run efficient maintenance and capital budgeting programmes, particularly of aging assets, they must know the conditions and current performance of their assets.

UK service providers have responded by producing some of the world's most sophisticated condition and performance monitoring technology. This includes equipment to monitor oil-filled cables, switchgear, steel and concrete structures. It also covers IT systems and software for modelling complex systems.

In addition, the UK's engineering and management consultants have developed decision-making tools and other analytical techniques for appraising asset management options.

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Developing frameworks for emerging civil nuclear power programmes

Impartial and technology-independent support over nuclear assets' entire lifecycles

The Lloyd's Register Group has worked on over 1,000 nuclear projects since the first UK reactor was built in 1950. Lloyd's Register has more than 200 nuclear experts, operating across the globe and focusing on the challenges of the design, siting and operation of future plants. The global challenges of climate change and energy poverty require solutions that have given rise to a worldwide renaissance in nuclear power.

Many countries are deploying or considering nuclear power for the first time because it is the only mature technology capable of generating electricity that is clean, secure, affordable and dependable. However, the decision to go nuclear is a

significant one, politically, financially and logistically. To bring a nuclear power station online is expensive and can take a decade or more to achieve. Lloyd's Register's nuclear teams provide independent and expert assurance by working with the governments of nations that are seeking to develop civil nuclear power programmes to supply advisory and technical services throughout the entire asset management cycle.

Lloyd's Register acts as a Technical Support Organisation (TSO) to governments that are starting to build new nuclear power frameworks according to international protocols, treaties and conventions.

Lloyd's Register also guides governments as they set up their own nuclear regulators and helps new users of nuclear power to complete investment appraisals, technical and financial due diligence and safety and risk assessments, as well as mapping out infrastructure requirements and building safe, secure and sustainable nuclear supply chains. All these tasks must be completed before a reactor design is selected.

Lloyd's Register plays a key role in the global nuclear renaissance by providing technical expertise and independent third party advice verifying safety reviews and their findings.

Advisory services

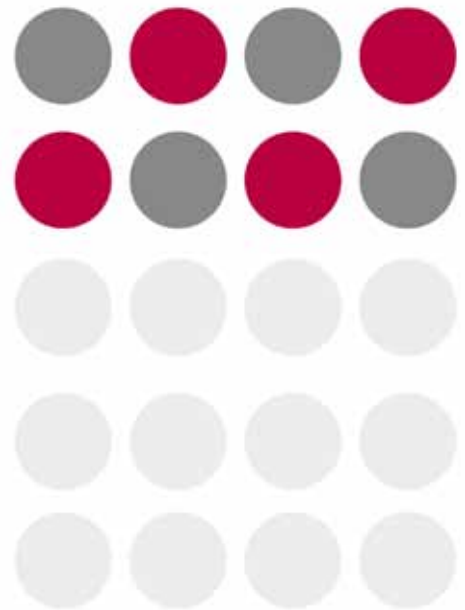
The UK has a strong tradition of providing professional advisory services to the power sector, delivering expertise developed over many decades. UK firms offer financial, legal and technical advice to cover every aspect of the power sector and its supply chain.

The UK's advisory services sector can draw on specific power sector expertise across virtually every business and technical discipline. It typically provides financial, legal, technical, IT, business and environmental expertise, or a combination of these. The power sector consumes vast sums of capital, which is facilitated by the unique and flexible UK financial sector, with its concentration of financial services institutions and experts in the City of London.

UK legal firms have been involved in drawing up and revising the regulatory enabling law, licenses and industry codes that together define the foundation of a jurisdiction's regulatory framework. UK law firms have been particularly active in unbundling and restructuring work, normally working with specialist technical advisers and management consultancies.

Understanding engineering and technology is critical to the performance of a project or transaction. The UK is home to several of the world's leading power engineering and related specialist consultancies. Engineering consultancies provide advice on other issues, too, including project feasibility, design, construction monitoring, project management, operation and maintenance, as well as likely operating regimes and decommissioning.

UK environmental advisers bring a comprehensive understanding of permitting and licensing processes, experience of stakeholder consultations, and expertise across the whole range of environmental science. They also provide guidance on management and monitoring. UK-based environmental consultancies also operate internationally, advising numerous governments on creating environmental regulations to suit local requirements and conditions.



Four of the world's top eight international law firms are based in the UK.



© Deloitte

Pre-feasibility study on new nuclear build in Europe

The UK-based nuclear team at Deloitte, a leading professional services firm, consists of a number of professionals with a broad range of financial and project experience in the nuclear industry. It has been a key adviser to the UK Government throughout the restructuring of the civil nuclear industry in the UK, both in terms of nuclear decommissioning and nuclear new build. The team is able to draw on a wide range of experience both within its UK firm and its other member firms, which consist of over 100,000 professionals.

Deloitte, leading a consortium of other advisers, has provided a comprehensive pre-feasibility study on the construction of a new nuclear power plant to a leading utility in Europe. This study covered a wide range of areas, such as legal, administrative and environmental aspects, an analysis of different contracting methods, a review of options around partnership structures and financial and economic analysis of the project.

Deloitte in the UK project managed the pre-feasibility study jointly with its local firm and drew on its broad range of capabilities and industry knowledge. Where necessary it was supported by technical and legal input, enabling a seamless review to be provided. This study has formed a key milestone for the utility in determining its investment options and programming the next steps for its new nuclear build programme.



In the last 15 years, UK-based power sector advisers have helped more than 30 companies invest in grid connected thermal generation projects, with a similar number of sale transactions for such plant”.

Financing the power sector

Economic and financial expertise to power energy sector growth

The UK's financial advisers include the major investment banks, boutique merchant banks, global accountancy practices and management consultancies. They provide a wide range of expert advice, including on project feasibility and returns, capital structures, sources of funds, loan syndication, taxation, and underwriting and insurance.

UK financial advisers have supported either the sponsor or lenders in the financing of many new power projects around the world. They have also played a key role in many of the largest mergers and acquisitions of power assets worldwide.

UK-based economic advisers play a key role in advising on the economic aspects of energy policy and regulations to help government and regulatory authorities assess the impact of their actions. Two key areas of expertise for UK consultants are price and performance controls, and performance regulation of monopoly service providers. UK economic consultancies have also built a strong reputation in understanding market design and trading systems, especially for power, gas, carbon and tradable green certificates.

The UK also has strong capabilities in energy market forecasting, with a number of consultancies offering detailed power market modelling and forecasting services. UK consultants have provided most of the market forecasts that have supported the financing of power projects since the early 1990s.

Managing the regulatory environment

Legal expertise that has written the power sector's regulatory rule book

The UK's legal sector is highly active, both domestically and internationally. Because the UK's power sector numbers so many world 'firsts', UK legal advisers are regularly called upon when fresh regulatory regimes are being prepared, or established ones are undergoing major change.

As a result of the UK's liberalised power market, the large number of transactions and early experience in liberalisation have broadened and deepened UK law firms' expertise in the power sector. This is reinforced by their involvement in the UK's extensive range of liberalised and regulated markets, as well as their work on major mergers and acquisitions.

The UK has very strong capability in addressing the complex regulatory, contracting and management issues raised by power marketing and trading. This includes assignments in support and development of power marketing businesses, as well as the more sophisticated requirements of project restructuring, asset disposition, gas tolling, arbitrage, asset optimisation and restructuring agreements. Where projects or transactions are financed by project loans, UK legal advisers will advise on key contracts, such as construction, fuel, sales and operations, which together make up the deal.

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Expert counsel on projects and legislative, regulatory and licensing regimes

Structuring power infrastructure projects in multiple jurisdictions

CMS Cameron McKenna has a market leading power practice that has advised internationally in over 40 jurisdictions and for over 25 years. The law firm offers expert counsel to industry participants at all levels of the power supply chain, from generators, network owners and operators to suppliers and regulators.

CMS Cameron McKenna regularly advises on the establishment or reform of legislative, regulatory and licensing regimes, with recent international examples including Botswana, Cambodia, India, Jordan,

the Kingdom of Saudi Arabia, Slovakia and South Africa. This has included the drafting of primary legislation, licences, tariff documents, codes, regulations and power procurement guidelines, together with areas such as nuclear decommissioning rules.

CMS Cameron McKenna also advises internationally on power station and other power infrastructure projects, and mergers and acquisitions (M&A). Recent projects include power stations and power infrastructure in the Balkans, Iceland, Kenya, Malaysia, South Africa and Turkey.

The firm has advised on the structuring of power projects and key documents, such as Power Purchase Agreements, Engineering, Procurement and Construction (EPC) contracts, off-take agreements, Grid Codes, connection and use of system agreements, Operation and Maintenance (O&M) contracts and financing documentation.

Developing frameworks for emerging civil nuclear power programmes

Impartial and technology-independent support over nuclear assets' entire lifecycles

Herbert Smith LLP has a world-renowned market-leading energy practice that advises on domestic and international projects which are at the cutting edge of new and emerging technology. A key component of the practice is its power team, which has advised on major developments in the power sector in the UK and internationally for 30 years, and a market regulatory team, which advises on major power sector reform projects.

The firm is currently advising the Nigerian Bureau of Public Enterprises on the privatisation of the country's electricity industry. The Nigerian Government has initiated these reforms in response to the country's shortage of generating capacity. The main objectives of these reforms are to restructure the power sector, unbundle the state-owned power company and privatise the unbundled generation and distribution companies.

Herbert Smith is advising on how to promote private sector participation in the unbundling of these assets while concurrently helping to secure early improvement in generation and distribution of electricity and ongoing asset operability in the country.

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Education, training and research

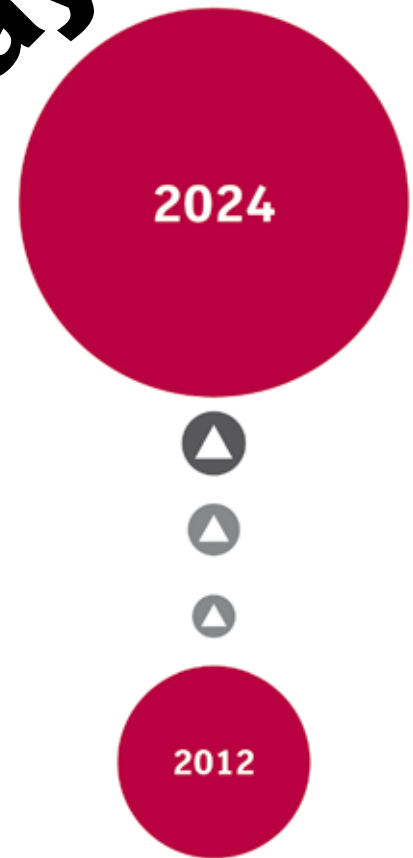
The UK has a vibrant research and development sector engaged in energy systems, power engineering and low carbon technologies.

UK organisations provide training and skills development on the operation of electricity assets, regulation and business activities in liberalised power markets worldwide.

World-class UK universities and research institutes are engaged in power and energy research across science, engineering and business disciplines. Research activities are spread across universities, institutes and private companies, much of it in collaborative projects being part-funded by Government. The UK Energy Research Centre (UKERC) and the National Energy Research Network (NERN) aim to coordinate the strategy and funding of the UK's Research Councils in the energy and power sectors. The Energy Technologies Institute (ETI) helps commercialise research linking power companies and the Government, and is forecast to receive over \$2 billion of matched Government and private sector funding for research over the ten years to 2017.

The UK's capacity for education, training and skills development in the power sector is extensive. It encompasses hands-on operating training of generation, transmission and distribution network workers, using state-of-the-art simulation tools, and bespoke, high-end technical courses. The level of training ranges from entry level trades and apprenticeships to post-doctoral and professional training. Education and training are delivered via a combination of private companies, universities and colleges, as well as through utility and energy companies. The number and variety of training service providers is huge.

Training and skills development in the UK's power sector is coordinated by the sector skills council, Energy & Utility Skills, the National Skills Academy for Power and the National Skills Academy for Nuclear.



By 2024, the number of UK-based quality training suppliers in the power sector is forecast to increase by 80%.



The Energy Technologies Institute (ETI) is forecast to invest over \$2 billion in energy and power related research over the ten years to 2017”.



World-class research and development

Leading university and corporate R&D facilities

More than a dozen leading UK universities have ongoing research programmes in power and energy related topics including basic and applied science, engineering and economics, management and policy. Many of the world's largest energy companies and engineering groups have UK-based research and development facilities. Corporate and academic researchers are active across the power sector and also complete research for international clients.

The UK Energy Research Centre (UKERC) is currently funding power-related research into nuclear energy, including

fusion, as well as into cleaner fossil fuels, plus renewable, hydrogen and fuel cell technologies. In addition, networks and storage research is being conducted to investigate how renewable energy sources, which have a very different supply profile to those of nuclear and thermal power, can be better integrated into the grid.

Skills provision for next generation power technologies

Equipping the global power workforce with fit-for-purpose skills

The UK offers hands-on operator training for power station operators, using state-of-the-art simulators. Advanced training is also given to transmission and distribution network workers. In addition, there is bespoke training on how to operate key power generation systems, often provided as part of a technical advisory service.

UK companies offer training on various aspects of electricity markets, including general overviews, energy trading, regulation and market operation, financing generation and asset management. Most of them provide bespoke training, in addition to open access programmes.

A number of major conference companies operate from the UK, providing conferences and seminars on electricity matters. In addition, several university business schools run academic post-graduate courses and other short courses on various aspects of energy markets and trading. Whether they are run in the UK or overseas, these events attract a significant proportion of delegates from outside the UK.



© The National Skills Academy for Power

Working smarter towards flexible power delivery

Smart grid and active network management research

The University of Strathclyde Institute for Energy and Environment, within the Department of Electronic and Electrical Engineering, is an internationally recognised research group driving advanced smart grid technologies. Twenty-six academics, 40 research fellows and over 140 research students are pioneering the technologies, concepts and policies that will deliver the low carbon, smart, electricity networks of the future. These include high-voltage direct current (HVDC) systems, power electronics, renewable energy technologies and integration, as well as active network management, power system protection and control, condition

monitoring and diagnostics. Another area of expertise is electricity markets and their regulation, including power system economics.

This incorporates the £5.5 million Engineering and Physical Sciences Research Council (EPSRC) Centre for Doctoral Training in Wind Energy Systems, and a £12.5 million Power Network Demonstration Centre that provides a realistic and controllable medium voltage and low voltage test bed for the development of smart grid technologies. The University of Strathclyde leads or participates in the EPSRC SUPERGEN (Sustainable Power Generation and Supply) Energy Network

Hub, Energy Network Grand Challenges, Highly Distributed Energy Future and Wind Energy programmes.

In addition to high quality academic research, the institute delivers applied and strategic research through extensive industrial research partnerships. These include the Rolls-Royce University Technology Centre in Electrical Power Systems, the SSE Research Partnership, the National Grid Partnership and the ScottishPower Advanced Research Centre.

A vital hub powering education and training

The National Skills Academy for Power (the Skills Academy) has a critical role in delivering the training and development needs of the UK's power sector. Through collaboration, the Skills Academy is developing the quality and consistency of training and education in the sector. It plays a vital role in delivering a sustainable pipeline of talent to meet the needs of the UK's power sector.

The Skills Academy takes a long-term strategic view of skills needs and training provision, addresses gaps in the provision and reduces unnecessary duplication. Its graduates work throughout the UK power sector, and their expertise boosts the skills UK firms bring to the export market.

Think Power is an initiative designed to make the UK's power sector more accessible and attractive. It allows the industry to highlight what it can offer in terms of a career pathway, job security, the variety of roles available, career development, training and, most importantly, helping to meet the future energy challenges. The Think Power website lists the opportunities available and provides essential information of how to start a career in energy and renewables and will be an essential starting point for those thinking about joining the industry.

Unique research facilities servicing the global nuclear sector

The expertise of the UK's National Nuclear Laboratory (NNL) covers the complete nuclear fuel cycle – from fuel manufacture and power generation, through to reprocessing, waste treatment and disposal. Its capabilities include defence, new nuclear build and homeland security. The National Nuclear Laboratory provides these services supported by an impressive range of facilities and links with international research organisations, academia and other national laboratories.

NNL's facilities are world-leading. Its UK-based Sellafield Central Laboratory is the most modern nuclear technology research facility in the world. Also on the Sellafield site is the Windscale Laboratory, providing Post-Irradiation Examination (PIE) and other services critical to plant life extension. At other National Nuclear Laboratory locations there are non-radioactive test rig facilities, a uranium active chemistry laboratory and teams researching graphite technology, radiation chemistry and modelling/simulation.

The ability of NNL to help build technical capacity for nuclear science and technology development both in the UK and internationally is based on its long-term operation of these world-leading facilities. It also has a wealth of technical experience, coupled with a significant network of global partnerships.

World-leading nuclear skills development

The National Skills Academy for Nuclear is an employer-led organisation established to ensure that the nuclear industry and its supply chain has the skilled, competent and safe workforce it needs to deal with the current and future UK nuclear programme, including all sub sectors. It works with employers and Cogent, the UK sector skills council for science-based industries, to deliver skills solutions specific to the nuclear industry's needs. These include the implementation of nuclear industry standards via the web-based Nuclear Skills Passport which has received a significant amount of international interest. A number of industry specific qualifications are also accessible via e-learning and the Skills Academy's network of high quality training providers.

The UK is recognised as a world-leader in nuclear skills. The Skills Academy's network of quality assured providers includes leading colleges, universities and flagship delivery centres, where overseas learners can study in the UK. Additionally there are international affiliates of the Skills Academy whose high quality training ensures employers across the globe can develop their nuclear workforce to the highest of standards.

The National Skills Academy for Nuclear has a formal collaboration agreement with the Institute of Nuclear Power Operations (INPO) and works closely with the World Association of Nuclear Operators (WANOP) and the International Atomic Energy Agency (IAEA). This ensures training provision is delivered to world-leading nuclear industry standards and qualifications.

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UK Trade & Investment

UK Trade & Investment is the Government department that helps UK based companies succeed in an increasingly global economy. Our range of expert services are tailored to the needs of individual businesses to maximise their international success. We provide companies with knowledge, advice and practical support.

UK Trade & Investment also helps overseas companies bring high quality investment to the UK's dynamic economy – acknowledged as Europe's best place from which to succeed in global business. We provide support and advice to investors at all stages of their business decision-making.

UK Trade & Investment offers expertise and contacts through a network of international specialists throughout the UK, and in British Embassies and other diplomatic posts around the world.

We can assist at all stages of the business planning cycle, from inception to completion. For an overview of what UK Trade & Investment does to foster companies' growth please visit www.ukti.gov.uk



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