Nuclear power

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Section Science and Environment

On 21 October 2013 the Secretary of State for Energy Edward Davey announced in a Statement that a deal had been reached between EDF Energy and the Government to build the first new nuclear power station in the UK since Sizewell B was brought on-stream in 1995. It will be funded by the private sector but will receive a guaranteed price for the electricity it generates.

This follows lengthy negotiations over the price to be guaranteed for the energy, the contract length, and attracting partners to share the cost. The negotiations have taken place during the passage of the current Energy Bill, which will introduce new 'contracts for difference' subsidy arrangements for all low-carbon forms of generation. These will replace the Renewables Obligation subsidy, which applies to renewables only.

The contract length will be 35 years, and the 'strike price' guaranteed will be £89.50, to rise in line with inflation. This is provided that Sizewell C is built as well, so that 'first of a kind' costs can be shared with EDF's subsidiary NNB Generation Company Limited (NNBG) building similar EPR reactors at both the Hinkley Point C and Sizewell C sites. If this does not happen, the strike price will be £92.50 for Hinkley C.

As part of the deal, under a Memorandum of Understanding on civil nuclear cooperation between the UK and Chinese Governments, EDF will be allowed to sell minority stakeholdings in Hinkley Point C to the Chinese companies, General Nuclear Corporation (CGN) and China National Nuclear Corporation (CNNC).

Subject to EU State Aid approval, it is highly likely now that nuclear power will continue to make an important contribution to the UK's electricity needs.

More information on generation and costs is available in the Library Standard Note *Nuclear Energy Statistics*.

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1 Government position on nuclear power

1.1 Nuclear's place in the mix

Assessments by Ofgem and National Grid of the UK's excess of generation over demand continue to point to the need for new generation to make up for coal closures. Ofgem's second (2013) *Electricity Capacity Assessment* said that the GB capacity margin (the excess of demand above supply) could fall faster than previously expected, to around 2-5% by 2015-2016 (compared to previous estimates of 14% recently and 20% previously).[1] National Grid's most recent security of supply Winter Outlook (October 2013) roughly agrees with Ofgem's but stresses that much depends on whether we have 'bad' winters.

UK and EU policy is for an open and competitive EU-wide electricity market. Currently, this is leading to investment within Europe in new coal and gas generation stations. A freer market in electricity benefits gas power stations because of the relative speed with which substantial generation can be built and the way in which the costs are spread over the lifetime of the plant.

By contrast, nuclear power and many renewables are capital intensive, requiring developers to commit substantial funds up front. If the need to reduce carbon dioxide emissions is factored in, then both nuclear and most renewables become more attractive as do energy conservation measures such as improvements to housing stock. There may additionally be scope for importing (nuclear-generated) electricity from France.

The Government's policy is for a balanced energy mix. Nuclear can be an 'always on' baseload source of power, complementing the intermittent nature of many renewable sources. Similarly, gas plant are 'flexible' generators than can be brought on-stream quickly

[1] Ofgem press release 27 June 2013 Ofgem report highlights the importance of government reforms to encourage more investment in generation

if renewables are unable to generate, for example if the wind is too strong to run turbines. A diversity of electricity generation options also contributes to energy security.

Nuclear power can certainly play a role in reducing carbon emissions, although a full comparison with other generation relies on a full life-cycle analysis of emissions, including the transportation of nuclear materials and the construction cycle. In the longer term new nuclear technologies may become feasible which rely on more abundant fuel sources or produce waste which presents less significant storage challenges, but these are currently at the research stage. There is more information in the POSTnote *Future Nuclear Technologies* (November 2008) and in the Library Note *Thorium energy* (24 June 2013).

Such considerations have led to the Government's position that nuclear power is part of the Government's energy strategy but will not come "at any price".[2]

1.2 Subsidy through the current Energy Bill

On October 2010, following the General Election, the then Secretary of State for Energy and Climate Change Chris Huhne made a Ministerial Statement in which he clarified the Government position on nuclear power:

> … I should like to take the opportunity to reconfirm the Government's policy that there will be no public subsidy for new nuclear power.
>
> To be clear, this means that there will be no levy, direct payment or market support for electricity supplied or capacity provided by a private sector new nuclear operator, unless similar support is also made available more widely to other types of generation.[3]

The current Energy Bill allows for subsidy to be provided to all low carbon generation, which tends to be more expensive up-front than other generation such as gas, for example. This will be done under a new mechanism called 'contracts for difference' (CfDs). Significantly, and unlike its predecessor the Renewables Obligation, CfDs will provide support to all forms of low-carbon generation, including nuclear.

The Energy Bill, currently in the Lords, provides for CfDs but also for statutory new nuclear regulation (through the Office for Nuclear Regulation). It was subject to pre-legislative scrutiny by the Energy and Climate Change Select Committee (ECCC). The Committee was broadly supportive of the need for new nuclear power, but was concerned that some saw CfDs and the Bill as a 'fig leaf' so that State support for new nuclear could get past any EU State Aid objections. It also said it would not expect a strike price for nuclear in excess of that for offshore wind, the other most upfront expensive generation option.[4]

The Bill also allowed for 'investment contracts' (or 'early-CfDs') to be agreed before the CfD regime was up and running, so that 'shovel-ready' projects could proceed. One such is Hinkley C. The Library research papers on the Bill provide more background.[5]

1.3 Past policy

The World's first nuclear power station was opened at Calder Hall (now on the Sellafield site) in 1956. In 1996 British Energy was privatised which, according to the *Financial Times*,

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2 HC Deb 19 Dec 2012 c957

3 Written Ministerial Statement on energy policy: The Rt Hon Chris Huhne MP, 18 October 2010

4 Library Research Paper 12/79, *Energy bill*, 13 December 2012, p30

5 Energy Bill 13 December 2012, Energy Bill: Committee Stage Report 12 March 2013 and Energy Bill 2013 - update for Report stage 30 May 2013

halted a project to build a fleet of pressurised water reactors (PWRs), which would have included Hinkley C and Sizewell C, the two sites now again next planned.[6]

There has been broad continuity in nuclear policy by recent UK Governments. In January 2008 the nuclear white paper, *Meeting the energy challenge* held that government should take active steps to facilitate investment in new nuclear plant. Following this, in 2009 the Labour Government arranged for the sale of British Energy, including eight of the UK's 10 operational plants, to EDF in a £12.5 billion deal. The then Energy Secretary Ed Miliband welcomed the move which would help meet carbon reduction targets. EDF said it would build four new nuclear stations, if the 'process' was made 'as fluent as possible', which would 'take time and would cost'. It was felt however that this 'paved the way' for new nuclear.[7]

The July 2011 white paper on electricity market reform (EMR) said: "The reforms set out in this White Paper will drive increased levels of intermittent renewable generation, and higher levels of inflexible generation, such as nuclear."

A debate on the Government's Nuclear Power Generation National Policy Statement took place on 18 July 2011. The national policy statements were all approved by the House of Commons, though the one on nuclear went to a division (the House approved this by 267 votes to 14). This made clear government policy on developing nuclear power:

> ... given the urgent need to decarbonise our electricity supply and enhance the UK's energy security and diversity of supply, the Government believes that new nuclear power stations need to be developed significantly earlier than the end of 2025.[8]

In March 2013 the Government published its Nuclear Industrial Strategy which expressed its hope that Hinkley Point C would be the first of five sites to be developed by 2030, and set out key actions and milestones.[9]

1.4 Hinkley C

Negotiations have been on-going between DECC and EDF for all of the time that the Energy Bill has been proceeding through Parliament.

In March 2013 Ed Davey, Secretary of State for Energy & Climate Change, announced authorisation for the construction of a 3.26 GW nuclear power station at Hinkley Point. In November 2012 it had been the first nuclear site to be granted a licence for 25 years.[10] Proposals for the plant were developed by EDF Energy, initially in collaboration with Centrica until the latter withdrew its participation in February 2013.

In a Statement to the House on the UK nuclear energy programme 21 October 2013, which will appear as delivered on the Parliament website in due course, Ed Davey announced several key points of the agreement reached:[11]

- Eight of the nine operational nuclear power stations in the UK will reach the end of their planned life in the next decade

6 Financial Times "*Hinkley deal details to be unveiled*" 21 October 2013 page 2
7 New Civil Engineer *EdF complete purchase of British Energy* 6 January 2009 and Business Green *EDF completes £12.5bn nuclear takeover of British Energy* 6 January 2009
8 DECC, *National Policy Statement for Nuclear Power Generation (EN-6), Volume I of II*, July 2011, p7
9 HM Government, "*The UK's Nuclear Future*", 26 March 2013
10 ONR, *ONR grants nuclear site licence for new UK power station*, accessed 10 May 2013
11 HC Deb 21 October 2013 c23

- Hinkley Point C will supply nearly six million homes or 7% of the UK's electricity by 2025.

- It will supported under Contracts for Difference for 35 years (around 60% of the 60 year operating life of the plant)

- The 'strike price' guaranteed will be £89.50 per megawatt hour, indexed to CPI.

- Hinkley C will be the first European Pressurised Reactor (EPR) in the UK.

- There is an upfront reduction of £3 per megawatt hour on the basis that EDF's subsidiary NNB Generation Company Limited (NNBG) will share 'first of kind' costs of the EPR reactors across the Hinkley Point C and Sizewell C sites; if Sizewell C does not go ahead, the Strike Price for Hinkley would be £92.50.

- Developers will be required to put £2 of the strike price aside in a protected clean-up fund to pay for eventual decommissioning and share waste management costs.

- Following the signing last week a Memorandum of Understanding on civil nuclear cooperation between the UK and Chinese Governments, two Chinese companies, CGN and CNNC, will invest in Hinkley Point C as minority shareholders.

The ECC Committee report Building New Nuclear: the challenges ahead published in March 2013 noted that the fact that EDF is French-owned had not had any discernible negative effects on attitudes towards the proposed new reactor at Hinkley Point C. The committee further noted speculation that a state-owned Chinese company might join consortia to build UK new nuclear. It noted also however that since Sizewell B was built,

> "much of the UK's nuclear supply chain has withered away. Similarly, the population of skilled nuclear workers is aging". [12]

The Committee concluded that a nuclear new build programme presented an opportunity to rebuild this industry and to create new job opportunities, given that potential suppliers had a proper understanding of the safety and quality requirements.

2 Safety: the impact of Fukushima

The Fukushima disaster in March 2011 prompted a re-examination of nuclear power, particularly from the standpoint of safety. Germany plans to phase out all its nuclear power plants by 2022[13] – which will likely see increased generation from coal, natural gas, and renewables (particularly wind power). The UK, on the other hand, remains committed to new nuclear build by a private sector encouraged by incentives for low carbon electricity generation. Following Fukushima, the then Secretary of State, Chris Huhne, commissioned a report from the Chief Nuclear Inspector, Dr Mike Weightman. His final report was published in October 2011. Both this and an interim report provided reassurance on the safety of existing and future nuclear stations – while counselling against complacency.

More background on the Fukushima disaster is available in a library standard note, *Japanese quake: nuclear power* (26 April 2011).

[12] Energy and Climate Change Committee, "*Building New Nuclear: the challenges ahead*", 4 March 2013
[13] Breidthardt, A., "German government wants nuclear exit by 2022 at latest", *Reuters*, 30 May 2011

3 Proliferation concerns

The uranium that fuels Britain's nuclear reactors is far from being weapons grade – further enrichment would be needed; something that requires fairly advanced centrifuge or diffusion technologies. Enrichment means increasing the relative proportion of uranium-235 compared to the far more abundant uranium-238.[14] The operation of nuclear reactors produces, among other things, plutonium. Again, this is not weapons grade though it may still be feasible (with greater difficulty) to use it in an atomic bomb.[15] However, radioactive material could be used to produce a radiological weapon (or "dirty bomb") in which conventional chemical explosives could be used to disperse it over a wide area.

Library Research Paper 10/42, *Progress towards nuclear disarmament?* (15 June 2010) provides details of the safeguards put in place by the International Atomic Energy Authority. The IAEA safeguards system functions as a confidence-building measure, an early warning mechanism and the trigger that sets in motion other responses by the international community if and when the need arises. A central purpose of the safeguards system is to prevent the diversion of fissile material for use in weapons and therefore under the safeguards agreement a state has an obligation to declare to the IAEA all nuclear materials and facilities under the agreement, update this information as necessary and submit its facilities to inspection and monitoring by the IAEA in order for it to verify its reports of declared nuclear material and activities.

4 Radioactive waste

In his statement on Hinkley C, the Secretary of State said that of the £89.50 'strike price' agreed for the power generated from Hinkley C, £2 would be for waste disposal and decommissioning:[16]

> Separately, and for the first time ever, to deal with clean-up costs of new nuclear, developers will be required to put money aside in a protected clean-up fund to pay for eventual decommissioning and share the waste management costs.
>
> This is anticipated to account for around £2 of the strike price.

EDF has produced an environmental appraisal for Hinkley C Volume 2 and Chapter 5 addresses decommissioning; section 5.3 outlines the Funded Decommissioning Programme that requires EDF to set aside funds during operation to cover this in full. Chapter 6 addresses spent fuel and waste.

Radioactive waste comes from a variety of sources including nuclear power generation, hospitals and scientific research. The management of such waste is a devolved matter with the devolved administrations of Scotland, Wales and Northern Ireland having responsibility for developing their own policies. The UK Radioactive Waste Inventory (last updated 1 April 2010) gives an overview of the quantities and locations of different levels of radioactive waste currently stored in the UK.

The scientific consensus is that the safest way to deal with nuclear waste in the long term is geological disposal (i.e. burial deep underground in a region that is geologically stable and where there is a small risk of seepage). A Library Standard Note, *Radioactive waste update* (15 February 2011) contains detailed background but, in brief: the long-term disposal policy

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[14] Uranium-235 and uranium-238 differ in the number of neutrons within the atom.

[15] House of Commons Library Research Paper 94/31, *The Nuclear Review*, 17 February 1994 p30

[16] HC Deb 21 October 2013 c23

for higher level radioactive wastes derives from the publication of the recommendation by the Committee on Radioactive Waste Management (CoRWM) in July 2006 that it should be in a deep underground repository known as geological disposal.[17]

In October 2006 the Labour Government accepted CoRWM's recommendation and gave responsibility for securing geological disposal to the Nuclear Decommissioning Authority (NDA).

The Labour Government proposed a voluntarism or partnership approach to finding a site for the repository under which communities would be invited to open up without commitment discussions with Government on the possibility of hosting the geological disposal facility in the future. Community benefits were expected to be provided after negotiation. Three expressions of interest were made by Copeland Borough Council, Cumbria County Council and Allerdale Borough Council, in West Cumbria.

Sellafield, where the majority of waste is currently stored, is in this region, with some level of its prosperity and employment dependent upon the nuclear industry. The 2012 DECC Annual Report on Implementing Geological Disposal said that public engagement had started in West Cumbria (and that Romney Marsh might be another possibility).

However, in January 2013 Cumbria County Council voted against the plans, effectively ruling out West Cumbria as a possible site for long-term geological storage.[18]

John Hayes MP, then Minister of State for Energy and Climate Change, stated in April 2013 that the invitation for communities to express interest remained open. He explained why the County Council's decision had been able to 'over-ride' those of the borough councils:

> With regards to the recent experience in west Cumbria, both Copeland and Allerdale borough councils decided to proceed to site identification and assessment, however, Cumbria county council did not. Since Government had given a specific commitment in west Cumbria that there should be agreement at both borough and county level before progressing to the next stage, this decision brought the existing site selection process to an end in west Cumbria.[19]

There is now a new DECC public consultation on proposals for a revised national site selection process, which has followed an earlier call for evidence. The consultation opened on 12 September and will run until 5 December 2013.[20]

5 Radiological protection

Radioactive materials emit ionising radiation which is a carcinogen.[21] The main aim of deep geological disposal of radioactive waste is to reduce human exposure to radiation to acceptable levels. For members of the public the relevant dose limit is 1 millisievert a year[22]; this compares with an average of dose of 2.7 millisieverts a year from natural sources.[23] In

[17] Managing Our Radioactive Waste Safely, CoWRM Doc 700, July 2006
[18] Cumbria County Council, *Managing Radioactive Waste Safely*, accessed 9 May 2013
[19] HC Deb 17 April 2013 c2MC
[20] HL Deb 8 October 2013 cWA27
[21] Public Health England, *Epidemiology FAQs*, accessed 15 May 2013
[22] HSE, *Information of doses*, accessed 15 May 2013
[23] Public Health England, *Dose comparisons for ionising radiation*, accessed 15 May 2013

some parts of Cornwall, the natural exposure can be up to ten times higher than this (from radon gas produced as a decay product – ultimately of the uranium present in granite).[24]

A good source of information on radiation exposure associated with the nuclear industry is a Health and Safety Executive document entitled the *Tolerability of risk from nuclear power stations* (1992). The following passage provides context:

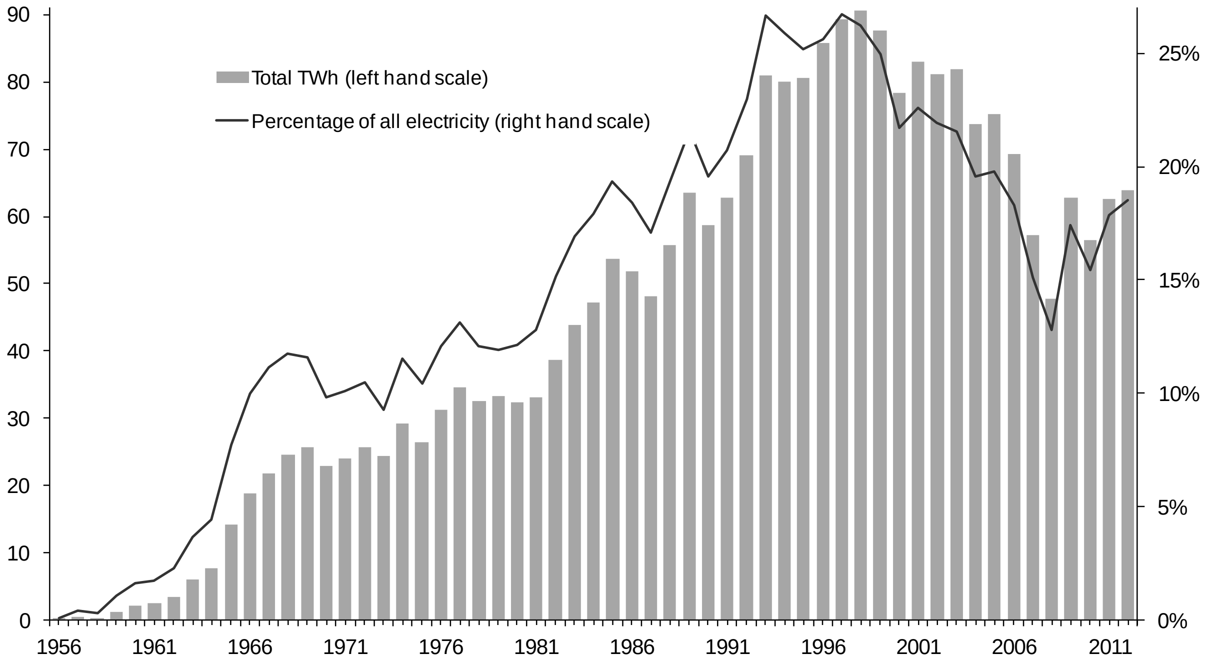
> A source which attracts a good deal of attention is radioactive waste. This currently gives rise to an annual dose, averaged over the whole population, of less than one thousandth of a millisievert (0.001 mSv), compared with more than 2 mSv from natural sources. Even the individuals receiving the highest doses from wastes are thought to get no more than 0.3 mSv per year.

6 Nuclear power's contribution to generation

Nuclear power remains an important part of the current and likely future UK electricity generation mix. Nuclear power stations have high capital costs but relatively low running costs. Once built, it pays to run them continuously, providing base-load electricity.

The Library Note *Nuclear Energy Statistics* looks in some detail at UK nuclear generation since the 1950s and includes a summary of nuclear generation in other countries and official projections of nuclear capacity. The chart summarises trends in UK nuclear generation.

Electricity supplied by UK nuclear power stations



Sources: *Digest of energy statistics, various years*, Ministry of Technology; *Digest of UK Energy Statistics*, DECC; *Energy Trends*, DECC

7 The cost of new nuclear compared to other generation

The Government regularly commissions research into the costs of new generation. These results are used to inform policy and the wider debate around the energy mix. The latest results are included in the DECC October 2013 *Electricity Generation Costs*[25].

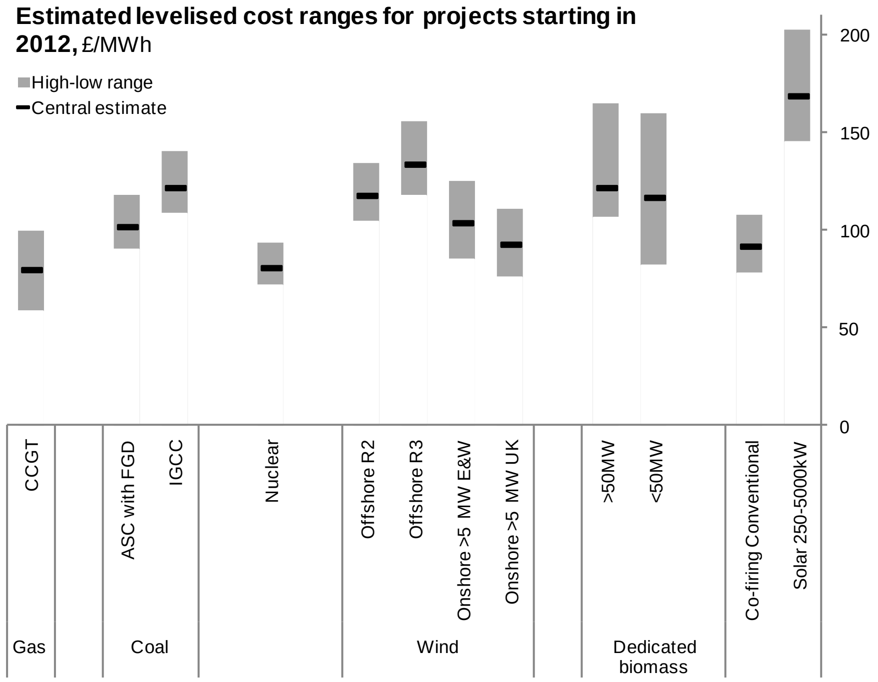
[24] *Ibid.*

The underlying research estimates the cost profile over the lifetime of each type of generation plant from the upfront pre-development costs to capital, fuel, maintenance, carbon, decommissioning and waste costs. These are discounted into present value terms using a ‘standard’ discount rate of 10% per year. This cost is compared to the total assumed lifetime output of each plant to get a £/MWh figure for each technology. This is known as the *lifetime levelised cost*. As the estimates are made for the cost of new rather than existing plant they look at a range of technologies from the well established to those still in development or with no commercial experience in the UK.

The costs for the first of a new type of technology are expected to be higher than when they become established. The costs data therefore include estimates for generation built now and in the near future when these ‘first of a kind’ costs are reduced. This is why the strike price will be lower if ‘first of a kind’ costs can be shared between Hinkley C and Sizewell C.

The charts below illustrate the central estimates of the levelised costs of different technologies, along with their high-low range, from the 2012 estimates.

The first chart looks at the main range of technologies considered appropriate for 2012 starts. Here gas and nuclear have the lowest central estimates of levelised costs at around £80/MWh. This is despite the first of a kind premium for nuclear. The high-low range for nuclear is also the narrowest of any of these technologies. Next least expensive are co-firing of biomass and onshore wind at £90-100/MWh. Offshore wind is more expensive, especially Round 3 sites which are expected to be deeper and further off shore than Round 2 sites.



2 **CCGT** -Combined Cycle Gas Turbine

3 **CCS** -Carbon Capture and Storage

4 **ASC** -Advanced Supercritical (coal)

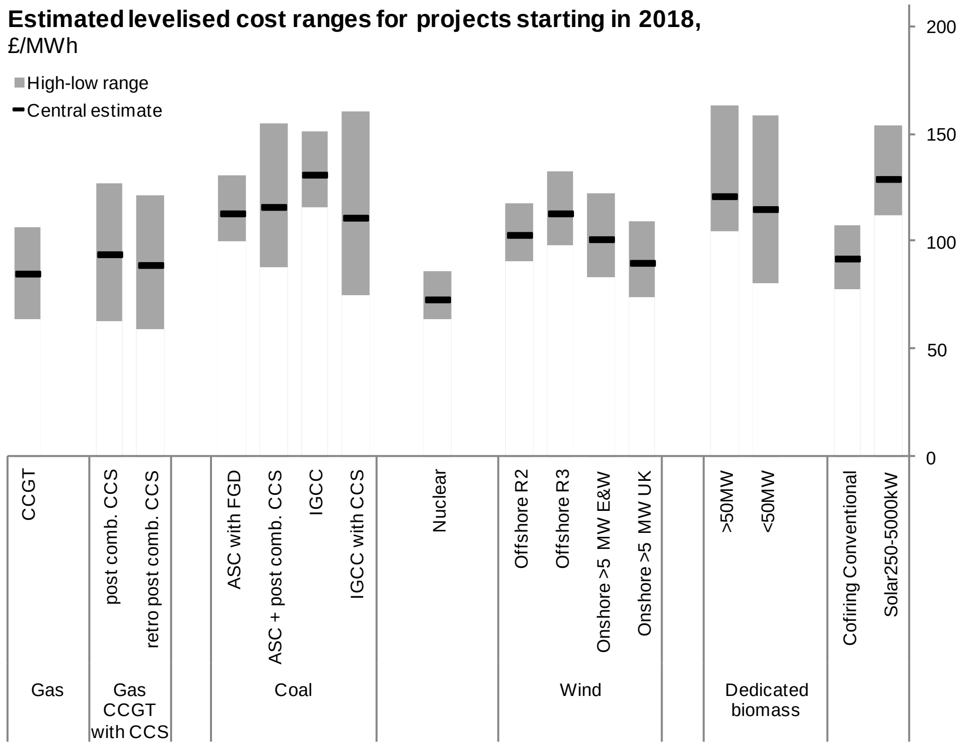
5 **FGD** -Flue Gas Desulphurisation

6 **IGCC** -Integrated Gasification Combined Cycle (coal)

The high-low range for CCGT starts in 2012 is wide for a conventional technology (£58-100/MWh). The sensitivities cover building costs and fuel prices and it is the latter that is the main cause of this relatively wide range.

[25] *Electricity Generation Costs*, DECC (October 2013)

The next chart looks at the main range of technologies deemed appropriate for 2018 starts. This includes coal and gas options with CCS, all of which have first of a kind premia attached. The later start date mean higher carbon costs for fossil fuel plants.



Here nuclear costs are lower than 2012 starts because the first of a kind premium no longer exists. Nuclear clearly has the lowest central cost estimate at £73/MWh (in 2012 prices) along with a narrow high-low range. The higher cost of carbon/capital costs of CCS push up the costs of the different gas options compared to wind and the other renewable sources. Central cost estimates for offshore wind are still higher than for gas, but their high-low range is narrower. All the different coal technologies have higher levelised costs than gas.

Further into the future the costs of new fossil fuel generation with CCS are expected to fall as the technology becomes established. The other main technologies that are expected to see substantial reductions in the levelised costs of new generation are offshore wind and large-scale solar plants.[26]

The lifetime levelised cost is strongly dependent on the chosen 'discount rate' which, in turn, reflects the level of real interest rates and the perceived investment risk of the project in question. While the costs of all types of generation are discounted at the same rate, they have different lifetime cost profiles and the choice of discount rate will therefore affect the cost comparisons. In very general terms where costs are largely upfront, for instance wind power, a higher discount rate will make it look relatively more expensive than other types of generation with costs which are spread out more evenly over its lifetime, for instance gas where fuel and carbon costs are a substantial element of total costs. Nuclear has relatively large upfront pre-development and capital costs, ongoing costs which are much lower than fossil fuels. Its decommissioning and waste costs at the end of its operating lifetime are very

[26] ibid. Table 3

large in absolute terms, but because they are so far into the future the impact of the 10% discount rate is substantial. For instance discounting at 10% per year means that £1 billion in 60 years time is viewed as the equivalent of £3.3 million now and £1 billion in 100 years time is viewed as the equivalent of around £75,000 now. An alternative way of thinking about the discounting process for the decommissioning and waste costs of nuclear is as payments into a fund with a 10% annual rate of return which needs to cover these costs when they arise.

The table below summarises the different elements of central levelised cost estimates for nuclear and a selection of other established technologies.

Levelised costs of main technologies by type, selected dates and assumptions

£/MWh

	Gas			Coal				Wind			Nuclear
	CCGT	CCGT + CCS	CCGT + retrofit CCS	ASC + FGD	ASC + CCS	IGCC	IGCC + CCS	Onshore >5MW UK	Offshore R2	Offshore R3	PWR
2012 start											
Pre-development costs	0			0		1		2	4	6	5
Capital Costs	9			22		26		71	81	91	55
Fixed operating Costs	3			5		7		17	32	37	11
Variable Operating Costs	0			1		1		3	1	-	3
Fuel Costs	48			28		30		-	-	-	5
Carbon Costs	19			45		56		-	-	-	-
Decommissioning/waste fund	-			-		-		-	-	-	2
Total Levelised Cost	**80**			**102**		**122**		**93**	**118**	**134**	**81**
2018 start											
Pre-development costs	0	1	1	0	1	1	1	2	4	6	4
Capital Costs	8	24	19	21	47	26	43	68	71	76	50
Fixed operating Costs	3	4	4	5	10	7	9	17	28	31	9
Variable Operating Costs	0	2	2	1	3	1	2	3	1	-	3
Fuel Costs	48	55	56	28	37	30	36	-	-	-	5
Carbon Costs	26	4	4	57	9	66	9	-	-	-	-
CO_2 transport and storage	-	5	5	-	11	-	11	-	-	-	-
Decommissioning/waste fund	-	-	-	-	-	-	-	-	-	-	2
Total Levelised Cost	**85**	**94**	**89**	**113**	**116**	**131**	**111**	**90**	**103**	**113**	**73**

Notes: All figures are discounted to 2012 prices using a 10% discount rate.

(shaded) Includes First Of A Kind premium

Source: Electricity Generation costs, DECC (October 2012)