It's Official: The United Kingdom is to subsidize nuclear power, but at what cost?

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Global Subsidies Initiative

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A review of planned subsidies to the proposed nuclear project at Hinkley Point finds billions of committed subsidies and the government on the hook for billions more if the project fails to deliver

Figure 1. Hinkley Point C CGI Image

Source: EDF Energy

The United Kingdom may soon be entering a new phase of development of nuclear power generation. It currently has 16 reactors that generate around one sixth of the United Kingdom's power, but no new plant has been constructed for more than 20 years. Much of the nuclear fleet will be decommissioned over the next 20 years as maintenance costs increase and it becomes impossible to meet the costs of complying with safety standards.

Support for Hinkley Point C began under the last Labour government. It has continued under both the Conservative–Liberal Democrat coalition and the current Conservative government. Backing was originally pledged on the basis that projects could be developed with "no public subsidy" (Cabinet Office, 2010, p. 17). Hinkley Point C in Somerset is the first of the new generation of plants to receive government backing—in October 2015, following the agreement of a long-term power purchase agreement at an above-market rate, the government finally conceded that the policy on nuclear subsidies had now been reversed (Department of Energy and Climate Change, 2015). Hinkley Point C is a 3.2 gigawatt (GW) nuclear power plant with two European Pressurised Reactors, and is part of a planned 16 GW of new nuclear capacity planned in the United Kingdom, with additional projects planned at Moorside and Wylfa. The levels of subsidy provided for Hinkley Point C are particularly important, as these will set a precedent for future projects.

Since nuclear subsidies are now again an official part of U.K. policy, it is reasonable to ask what subsidies are proposed and how much these will cost.

The research shows that, due to the kind of subsidies designed, it is not possible for the government—or anyone else—to estimate with certainty the overall cost to the public. The U.K. government is in the process of signing a blank cheque to the industry, promising to pick up the cost of technical problems, financial failure, waste disposal and nuclear accidents, if these costs rise beyond predefined levels.

Subsidies have been a part of nuclear policy since the beginning of the industry. No project has proceeded anywhere without government limits on liabilities for accidents, for example. What is new about Hinkley Point C is the exceptional duration and the high price to be paid for the electricity relative to current wholesale prices.

The electricity generated at Hinkley Point is to be purchased at a fixed price through the Contract for Difference (CfD). The CfD is often referred to as if it is the only subsidy the project will receive. In fact, it is just one of a comprehensive package of subsidies. Other significant subsidies include:

- **Government-backed loan guarantees** that will protect lenders from the risk of default.
- **The cost of waste disposal** to the operator will be capped and the government will have to cover any shortfall.
- **The clean-up cost of a nuclear accident** will also be capped, with the government effectively providing insurance to the project.
- **The costs of decommissioning the project** will also be covered in large part by the government.

Available estimates of these subsidies are presented in the table below. More detailed descriptions of each element can be found in subsequent sections.

Table 1. Available Estimates of Subsidies

NAME	DESCRIPTION OF THE SUBSIDY	COST (IN 2015 GBP)
Price guarantee	Guaranteed price paid for power over 35 years from date of first production.	UNCERTAIN • Unit cost approximately would be GBP 45 per megawatt hour (MWh) if plant was generating today and rising over time with inflation. • Total cost over 35 years: GBP 4–19 billion (government estimate) GBP 3–40 billion (GSI calculation, see below). • Average per unit costs over the life of the plant are between GBP 3.4–44.4 per MWh.
Loan guarantees	Government guarantees debt allowing the developer to get lower-cost credit.	UNCERTAIN • GBP 17 billion of loan guarantees are to be issued. • If loan guarantees lead to a 2-5% reduction in interest rates, the GSI estimate that the value could be as much as GBP 7.5–18.4 billion over 35 years (GBP 8.2—20.3 per MWh) .
Waste disposal	Capping of waste disposal costs	UNKNOWN • Current estimates indicate that waste disposal costs should be GBP 2.3bn and if they rise over GBP 5 billion the government would be forced to cover further increases.
Limitation of liabilities	The government has placed a cap on the value that nuclear operators are liable for reducing the cost of insurance.	UNKNOWN • Estimates for the full cost of insurance vary between GBP 17.2–3,868 billion (GBP 0.8–180 per MWh): this range is so large as to be of little use in determining true costs. • Cost is highly dependent on perception of the probability of nuclear accident.
Decommissioning costs	Cap on decommissioning costs.	UNKNOWN • Developers must submit a costed decommissioning plan, but cost overruns will ultimately be the responsibility of the government.

Contract for Difference (CfD) Price Guarantee of GBP 92.50 per MWh

The primary mechanism to drive investment in new nuclear power stations is that generators will receive a guaranteed price for electricity. In the case of Hinkley Point C a "strike price" of GBP 92.50 per MWh has been negotiated by Electricity De France (EDF), the plant operator, with the value being linked to Consumer Price Inflation (CPI) inflation for a duration of 35 years. The strike price drops to GBP 89.50 if EDF also develop the Sizewell C site. The operator will receive a transfer that compensates for the difference between power prices and the strike price. The cost of the subsidy will be covered by a charge on consumers' bills. If the wholesale price of power is higher than the strike price, then the operator pays the difference to the regulator. The indexation of the strike price is effective from the date of the agreement in 2012 even though Hinkley Point C is not expected to be operational until around 2025, and perhaps considerably later.

The cost of providing the subsidies depends on prevailing electricity prices, yet these are impossible to credibly estimate over such long timescales. A 35-year subsidy which may not begin for a decade means the cost of the subsidy depends on power prices in up to 45 years' time. Making commitments of this length with large uncertainty has a serious risk of locking-in an expensive subsidy for decades.

The level of certainty provided by the CfD provides an opportunity for the nuclear industry to receive certainty of revenues over a longer period than every other actor in the market. Most investors face risks of new technologies undermining the viability of their assets as part of the normal business environment. Hinkley Point C will not face this risk.

The current average wholesale price is around GBP 47.50, so, using this as a benchmark, the generator would be effectively subsidized GBP 45 for every MWh of generation. However, as most power is not traded on the market, but contracted over longer periods, this price may not be a fair reflection of typical power prices. Putting aside this concern and assuming that this level of subsidy continues over the whole 35 years of the agreement then the total subsidy would be around GBP 19 billion once discounted to 2015 values.[1] In reality, wholesale electricity prices will change over time.

The government's own estimates report the cost of the CfD subsidy to be between GBP 4 billion and GBP 19 billion, though the government has also claimed that Hinkley Point C "could" reduce consumer electricity bills by GBP 75 a year in 2030, compared to a future where nuclear is not part of the energy mix (DECC, 2013). These seemingly conflicting statements can only be reconciled if power price rise higher than the index linked strike price. Presumably the range

[1] Assuming a 3 per cent discount rate in line with the HMRC Green Book, a government guide to economic modeling for the United Kingdom.

takes into account the possible variation in future power prices. However, as the calculations behind these figures are not available it is impossible to critique the underlying assumptions.

To illustrate the influence of power prices on the subsidy cost two different scenarios have been developed; the first assumes that inflation is 2.5 per cent for both the strike price and the reference price, and a second where the rate of inflation for reference wholesale power is greater (at 5 per cent). These values are based on past trends in inflation. Average CPI has been 2.1 per cent or 2.7 per cent over the last 20 and 10 years respectively. Inflation of wholesale power costs was taken from the electricity element of CPI, which was 5.3 per cent over the last 20 years. Factors such as carbon pricing or changes to the energy mix have not been considered in the analysis. Historically, energy price inflation has outstripped CPI, but this trend may not continue in an era of historically low oil prices and technological innovation in both renewable energy and oil production. For example, solar panel costs have fallen by an average of around 6–8 per cent per year since 1998 (Feldman et al., 2014), and hydraulic fracking has increased recoverable oil reserves enormously in the United States.

Assuming the rate of inflation is the same for both prices and discounting to 2015 prices, the total net present value of the effective subsidy is GBP 40 billion for the lifetime of the contract. If wholesale power shows inflation of 5 per cent (as in our second scenario) then the price will exceed the strike price in around 2044 after which the operator would then pay the difference to the regulator. Overall this works out to an effective subsidy of GBP 3 billion over the 35-year contract. It is worth highlighting again the sensitivity of the level of subsidy to inflation and therefore the uncertainty in the eventual cost of the subsidy. For example if we reduce inflation of wholesale power by 1 percentage point then we add an additional GBP 17 billion of subsidy.

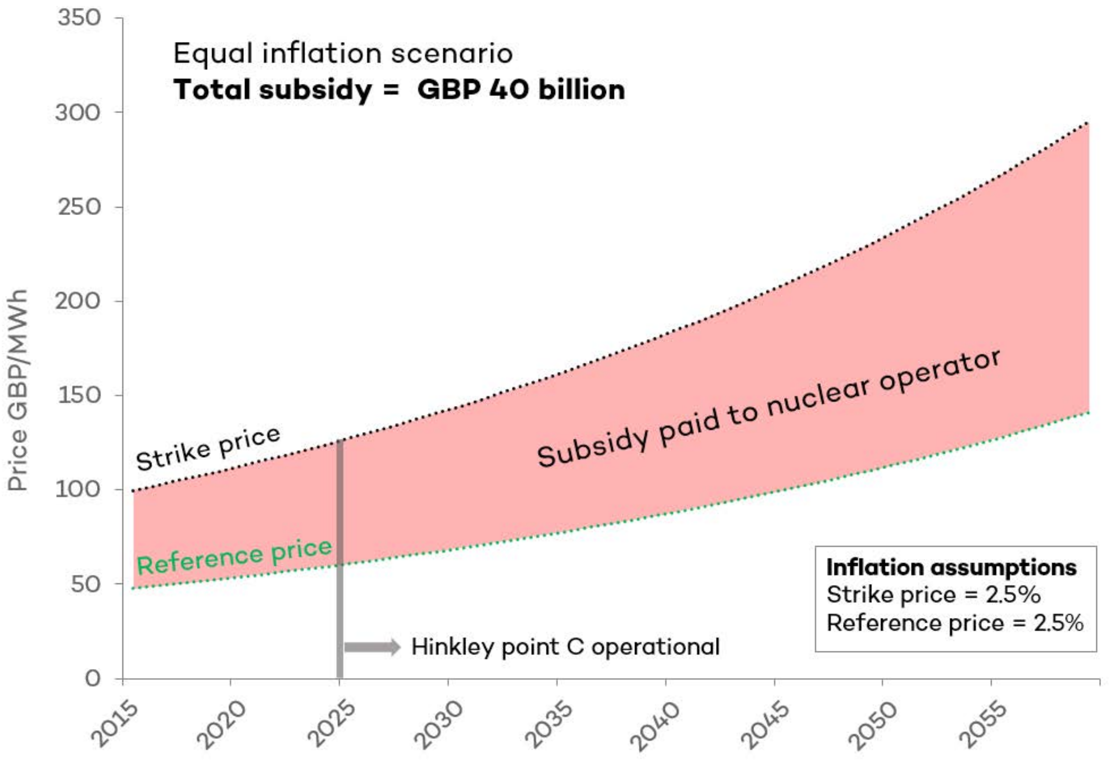

Figure 2. Strike Price Subsidy: Equal inflation scenario

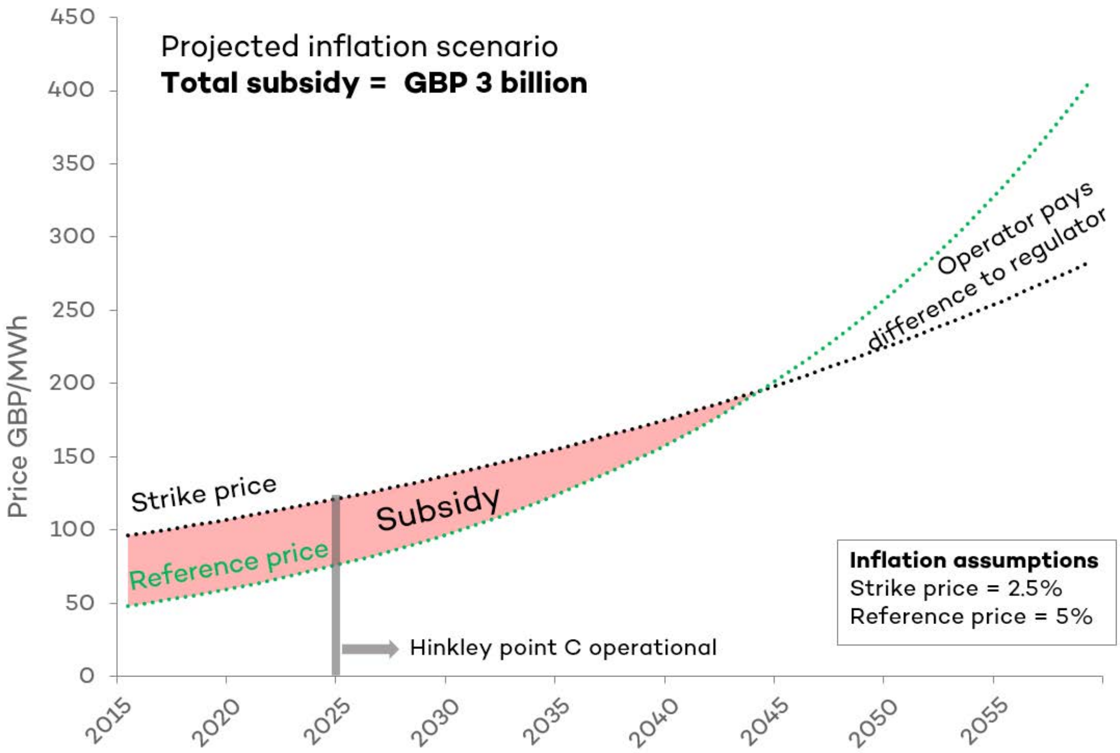

Figure 3. Strike Price Subsidy: Projected inflation scenario

These projections indicate that the subsidy could be as much as GBP 40 billion or as little as GBP 3 billion. If the Sizewell C site is also developed and the GBP 89.50 strike price is used this changes to a range of GBP 1 billion to GBP 38 billion. It should be noted that these two examples do not describe the full range of possible scenarios. Power prices may evolve in unexpected ways, far from the smooth price inflation depicted in the charts above.

There is a clause built into the contract for the option to renegotiate the strike price after 15 and 25 years of operation to account for long-term changes in costs. These estimates illustrate that the cost may be very considerable if power prices remain lower than the government has assumed and there is huge uncertainty in the eventual cost of supporting Hinkley Point C. The presence of other generators with low marginal costs, such as renewables, could act to depress market prices. This phenomenon has been described in Germany as the "missing money problem." If replicated in the United Kingdom this could lead to even higher costs for subsidizing nuclear power (Hildmann, Ulbig & Andersson, 2015). If Hinkley Point C is just the first of a new generation of nuclear power plants this uncertainty will be further amplified.

Loan Guarantees

The UK Guarantees scheme for infrastructure provides a commitment to lenders and bond investors to infrastructure projects that they "unconditionally and irrevocably agree to pay to the beneficiary any such amounts which have become due for payment" (Allen & Overy, 2013). The scheme was introduced in 2012 to encourage lending to infrastructure projects in response to perceived difficulties in obtaining credit for infrastructure.

The scheme is designed so that the government charges for providing the loan guarantee to projects. According to State Aid Documents, this charge will be equal to 2.95 per cent of the loan. The charge is supposed to be equal to the cost of offering the loan guarantee, though this is difficult to verify due to the lack of similar schemes. Since the loan guarantees are not designed to give preferential rates, the scheme is able to avoid state aid restrictions. However, if the charge really was equal to the market risk of the loan, finance would be available from the market under the same terms—this is clearly not the case. As of January 2015 the scheme had pre-qualified GBP 24 billion worth of guarantees. Hinkley Point C is by far the largest project in the scheme, accounting for approximately 70 per cent of the pre-qualified projects.

Loan guarantees can provide credit support to the project. Lenders effectively transfer project risk, including that of cost overruns or delays, to the government. This significant reduction in risk enables more lenders to consider the project, increasing competition and reducing the interest rate that the project will have to pay. The presence of loan guarantees removes the need for lenders to carry out rigorous due diligence, as they don't stand to lose billions if the project should fail. Lender due diligence is a key mechanism for scrutinizing project economic models.

If Hinkley Point C were to operate at a loss and was unable to service its debt the government would be required to make interest payments that could amount to of billions of pounds. The U.K. Government claims that the costs of providing loan guarantees are being covered by a charge of 2.95 per cent on the guarantee. However, in a recent state aid ruling the European Commission described the credit guarantee has having "unparalleled value" and concluded that charge for the guarantee cannot be considered a market price as the market does not and would not provide a similar facility. However, despite noting the challenges of reaching a market price in the absence of a market they eventually concluded that the adjusted charge "limits aid to the minimum." In the United States, the company developing a new nuclear plant at Calvert Cliffs in Maryland estimates that government loan guarantees will save USD 0.037 per kWh on a levelized cost basis, a saving of nearly 40 per cent from the company's "no guarantee scenario" (Koplow, 2011). This illustrates that even if projects manage to pay back loans and there is no direct cost to the government, the companies receiving the loans still benefit financially. If projects do default, the direct costs can also be very high. A report by the Union of Concerned Scientists reported that around half of US Department of Energy Loan Guarantees ended in default (Koplow, 2011).

Methodologies designed to estimate the cost of the loan guarantee to governments compare the cost of obtaining debt including project risk with the cost of borrowing the same level of funds with no prospect of defaulting (Congressional Budget Office, 2011). If no subsidy is present the charge for the loan guarantee should be equal to the difference between the low-risk and high-risk interest rates. In practice, the risk of default and therefore an appropriate rate of interest is extremely hard to determine. A discussion of how to value government loan guarantees is presented by Lucas (2013).

It is not possible to make a detailed calculation of the cost of the loan guarantee for Hinkley Point, but it is possible to do some ballpark estimates to give an indication of the potential cost. Typical nuclear industry Weighted Average Cost of Capital (WACC) has been suggested by Harris, Heptonstall, Gross, and Handley (2013) as around 11 per cent. According to state aid submissions the WACC of regulated infrastructure, a low-risk utility sector investment, is of the order of 4–5 per cent. Taking into account the charge of 2.95 per cent for the loan guarantee, the nuclear energy project stands to see a reduction in the cost of borrowing (equal to the public subsidy) of around 2–5 per cent. This range implies a reduction in the borrowing costs to the project of GBP 8.2 to 20.3 billion in 2015 pounds. Only time will tell whether the Hinkley Point C project experiences delays and eventually defaults on its loans, but—given the history of nuclear industry cost overruns and defaults—it is a distinct possibility.

Further work is needed to develop a detailed estimate of the support component of the loan guarantees available for the Hinkley Point project building on the "ratings-based" approach described by Lucas (2013). The financial industry would be able to give a view on the true value of loan guarantees relatively quickly.

Waste Disposal

In conjunction with the contract for difference, the government will also enter into a Waste Transfer Contract (WTC) with the operator, which requires the government to provide a waste disposal service for spent fuel and intermediate-level waste. The government manages all disposal services for nuclear plants in the United Kingdom. The price of these contracts is set according to the government's waste transfer pricing methodology (Department of Energy and Climate Change, 2011) and is capped at GBP 5 billion. If waste disposal costs exceed this any further costs will be effectively passed to the government.

The costing of the WTC assumes that waste will go to a geological disposal facility and includes a contribution to capital costs for this. The price of the contract will not be set until around 2050, when it is hoped that a site for geological disposal has been selected and costs are more certain. The cap will be set ahead of this, however, and will continue to apply even if the government were to change its policy and adopt a more expensive route for the long-term management of the waste. The expected payment under the WTCs for waste disposal is currently around GBP 2.3 billion for Hinkley Point C. This could rise to around GBP 5 billion before the cap became applicable. The European Commission has considered the methodology used under the WTCs and concluded that they do not constitute state aid (European Commission, 2012).

By comparison, recent estimates of total costs for a geological disposal of waste facility, including disposal of "legacy" waste, are GBP 4.32 billion discounted to 2011 prices not including the processing, packaging or transportation costs (Nuclear Decommissioning Authority, 2012). Experience from elsewhere suggests that permanent storage solutions are not easy to deliver. Delays to the Yucca mountain project in the United States for example are estimated to have led to utility lawsuits that will are cost taxpayers about USD 12.3 billion by 2020 (Government Accountability Office, 2009). Most countries do not have operational sites with sufficient storage to deal with existing and expected waste from nuclear plants.

The government states that the price cap is very unlikely to be breached, but acknowledges that the cost implications could be significant if they are. Estimation Bias—the tendency to underestimate the cost of construction projects during the conception phase—would suggest that upward revisions of the construction cost of nuclear storage facilities are relatively likely because of the uncertainties associated with the future costs of waste disposal: it is simply not possible to say what the cost will be and whether it will exceed the cap.

There is considerable uncertainty around the costs of nuclear waste disposal. Under the current arrangements operators receive certainty regarding the cost of disposal, due to the cap on disposal costs. This removes a risk that they would normally have to manage and so improves their commercial position. If waste disposal costs exceed the cap, the government will end up facing direct costs from waste disposal. This risk does not exist for any other form of power generation; the disposal challenge is unique to nuclear power.

Decommissioning Costs

The Energy Act 2008 requires prospective operators of new nuclear power stations in the United Kingdom to have a Funded Decommissioning Programme (FDP) approved by the Secretary of State before nuclear-related construction can begin. This must set out the operator's costed plans for decommissioning the power station and management and disposal of the waste it will produce, and make prudent financial provision for those costs. The aim of this policy is to avoid the government footing the bill for the decommissioning of nuclear plants, as has been the case in the past.

Previous generations of nuclear power stations, fuel processing sites and other parts of the United Kingdom's nuclear legacy are currently decommissioned by the Nuclear Decommissioning Authority (NDA). The NDA reports total estimated lifetime costs of around GBP 70 billion discounted to 2014/15 (National Audit Office [NAO], 2015). Nuclear Decommissioning accounted for approximately GBP 2.2 billion, 65 per cent of DECC's total budget in 2013/14 (Carbon Brief, 2015). Estimates for the cost of decommissioning legacy nuclear plants have risen in recent years, in particular at the Sellafield complex, where between 2010/11 and 2013/14 decommissioning costs for various legacy facilities increased by more than GBP 15 billion (National Audit Office, 2015). The recent history of decommissioning estimates being revised upward casts doubt on the ability of the industry to predict future costs. In the case of Hinkley Point C the estimates are attempting to predict decommissioning costs for many decades in the future.

Details of the FDP for Hinkley Point have not been released. A Freedom of Information request was declined (DECC, 2012). However, in a statement in the House of Commons Edward Davey stated that decommissioning costs were expected to account for around GBP 2 of the strike price (Hansard, 2013).

The lack of transparency over decommissioning plans and the inability to accurately predict nuclear decommissioning costs creates the distinct possibility that the government would ultimately need to step in to provide additional funding to decommission Hinkley Point C. The commitment by government to manage decommissioning cost overruns could constitute a subsidy to the project, though it is not possible to understand the magnitude of this subsidy because future cost overruns will only become apparent as decommissioning takes place. Historically, decommissioning has come at a considerable cost, accounting for a large percentage of all spending on energy projects.

Limitations of Liabilities

The U.K. government has mandated liability insurance is required for nuclear operators up to a level of GDP 1.2 billion (DECC, 2015b). If the cost of the clean-up from nuclear accidents exceeds this amount the government must meet any additional costs. If nuclear operators were required to meet the full costs of any potential disaster they would have to pay considerable insurance premiums. The liability cap can therefore be considered as a subsidy.

If available, the cost of providing insurance would be a function of the value of the damage caused by a nuclear accident and the likelihood of such an accident occurring. Estimates vary for the cost of major historical accidents vary. The Fukushima Daiichi disaster cost an estimated USD 200-500 billion (Starr, 2015), Chernobyl was estimated to cost several hundreds of billions of dollars and Three Mile Island an estimated USD 1 billion (Lévêque, 2013). The probability of an accident is much harder to calculate—today's reactors, such as the European Pressurized Reactors (EPRs) planned for Hinkley Point C are often claimed to be safer than previous generations but very little data exists to verify this. The difficulties of estimating the probability of a major disaster are a major source of uncertainty and account for the wide range of estimates. A study by German Actuaries Versicherungsforen Leipzig (Versicherungsforen Leipzig, 2011) estimated that an appropriate insurance premium would add a per unit charge of EUR 0.139 to EUR 2.36 per kWh while a similar estimate by Lévêque (2013a) estimated just EUR 0.01 per kWh. The difference between these rates indicates the enormous level of uncertainty. If the cost of insurance is as low as some of the more optimistic estimates suggest it would seem reasonable to increase the level of insurance cover that nuclear plants must hold.

Undoubtedly if a major disaster were to take place at the Hinkley Point C project the cost to the U.K. government would be enormous. If the likelihood of such an event taking place was found to be above all but the lowest estimates, and if operators were required to provide insurance to cover all eventualities, the premiums would likely be high enough to have a material impact on the viability of nuclear power generation. A key question is who should bear the risk of a major nuclear accident, and in what proportion? The nuclear operators probably have the best information to be able to assess the risk and they will be in control of the operations that will ultimately prevent a catastrophe but they may not have the financial ability to survive such an incident. The unique position of the government, accountable to the public and with the financial power to withstand disasters also creates a case for the government to assume risk. The current risk-sharing settlement effectively removes the risk of bankruptcy from the nuclear industry by providing a subsidy. Understanding the true cost of this implicit insurance is a key to weighing the costs and benefits of nuclear power.

Summary

The key story that emerges from the picture of nuclear subsidies is one of uncertainty. The Contract for Difference (CfD) provides a guaranteed price for power generated at Hinkley Point and confers a subsidy of between GBP 3 to 40 billion over 35 years, depending on future energy prices. Loan guarantees imply a further subsidy of GBP 7.5–18.4 billion over the same period. On a per-unit basis the combination of these gives a subsidy of between GBP 11.6 – 64.7 per MWh over the life of the scheme. This commitment is already an enormous cost to the public. In addition to the Contract for Difference subsidy, the provision of loan guarantees, limits on liability and decommissioning costs, all present further subsidies that are very difficult to quantify but are likely to be costly based on historical experience.

A number of key risks face the Hinkley Point project, all of which may force the government to step in to cover unforeseen costs. Due to technical or project management challenges, construction may take longer than anticipated, pushing the project into bankruptcy, thus triggering loan guarantees and forcing the government to repay lenders. Decommissioning costs are incurred far in the future and have historically been subject to enormous rises and overruns due to the complexity of dismantling potentially hazardous systems. Waste disposal facilities may take longer to construct and cost more to manage leading to additional costs for the government. Given the history of nuclear power in the United Kingdom, cost overruns and delays should be considered likely.

All of the subsidies described here should be considered as non-binding and still subject to negotiation—as the Hinkley Point C project moves toward financial close the developers may seek final concessions including still-higher subsidies under the guise of ensuring financial sustainability.

The risk of a nuclear accident casts a long shadow over the nuclear industry. The Fukushima Daiichi disaster has caused a widespread rethinking of whether the risks of nuclear power can be managed. If an accident were to happen, it could cause untold damage and with insurance capped at EUR 1.2 billion the government would stand to cover most of the costs.

The known subsidies in themselves already place the cost of nuclear power above most other technologies, including onshore wind, and the additional, as-yet unquantified, subsidies create a risk that nuclear could be far more expensive than all other options if one or more of the conditions described above occurs.

The proposed package of subsidies represents an enormous opportunity cost, shaping the United Kingdom's energy system for several generations and preventing the country from investing in other technologies, particularly renewables, that are much less risky and can be financed without so many open-ended commitments.

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