AN OPTIONS APPROACH TO UNLOCKING INVESTMENT IN CLEAN ENERGY

THE BANKING ENVIRONMENT INITIATIVE (BEI) **NOVEMBER 2012**

UNIVERSITY OF CAMBRIDGE
PROGRAMME FOR SUSTAINABILITY LEADERSHIP

THE BEI IS A GROUP OF LEADING INTERNATIONAL BANKS LOOKING FOR WAYS TO DIRECT CAPITAL TOWARDS SUSTAINABLE, LOW CARBON GROWTH AND AWAY FROM ACTIVITIES THAT UNDERMINE IT

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About the Banking Environment Initiative (BEI)

The BEI was convened by the Chief Executives and Chairs of some of the world's largest banks in 2010 to identify new ways in which banks can collectively stimulate the direction of capital towards sustainable, low-carbon growth and away from activities that undermine it. The secretariat is provided by the University of Cambridge Programme for Sustainability Leadership (CPSL).

The BEI has been laying the foundations for an exciting new approach to tackling key sustainability issues through innovative bank-corporate partnerships. Two partnerships have been pioneered initially, drawing on CPSL's experience of developing business-led collaboratories: time-bound, problem-solving groups which focus on particular sustainability challenges.

This report is the product of the BEI Collaboratory on Clean Energy, which was delivered through a partnership between BEI members and a group of oil and gas and electric utility companies. Its central aim was to find ways to unlock greater mainstream investment in clean energy. This is complemented by an independent evidence base compiled by experts at the University of Cambridge's Judge Business School (JBS).

Acknowledgements

This report was written by **Dr Chi-Kong Chyong** (Research Associate, JBS) and **Andrew Voysey** (Senior Programme Manager for the Finance Sector, CPSL). Expert guidance and review was provided by **Professor Daniel Ralph** (Professor of Operations Research, JBS), **Dr David Reiner** (Senior Lecturer in Technology Policy, JBS), **Dr Jake Reynolds** (Deputy Director, CPSL) and **Richard Burrett** (Senior Associate, CPSL).

This report was championed and guided throughout by members of the BEI Collaboratory on Clean Energy, which comprised BEI banks (**Barclays**, **Deutsche Bank**, **Lloyds Banking Group**, **Nomura**, **Northern Trust** and **Westpac**) and energy companies (**BG Group**, **DONG Energy**, **Duke Energy**, **EDF Energy**, **RWE npower** and **Shell**).

This report, as well as its Technical Annex, can be downloaded from www.cpsl.cam.ac.uk/bei.

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Executive Summary

Summary of the Summary

1. Valuation methodologies like Discounted Cash Flow (DCF) do not, on their own, offer an explicit way to incorporate uncertain future market or policy conditions that could have asymmetric impacts on investment performance into valuations.
2. Nor do they account for managerial flexibility to respond as uncertainties are resolved.
3. Clean energy investments are particularly exposed to this set of conditions, so such tools could lead to suboptimal investment decisions if not used appropriately.
4. A group of banks and energy firms has assessed clean energy case study investments in three market contexts compiled by the University of Cambridge's Judge Business School.
5. We conclude that where these conditions of uncertainty exist, enhancing valuation methodologies with approaches that explicitly value embedded optionality to respond should become standard practice. This would formalise some existing market practices.
6. Implications are drawn for equity investors, company boards, providers of debt and policymakers.

Equity investors and company boards are facing a challenging set of policy and market conditions in the energy sector.

2011 saw more investment globally in new renewables than in new fossil fuels.[1] However, governments are still creating significant uncertainty around key energy policies in various markets, as well as around new market signals such as the price of carbon.

If uncertainties are not appropriately incorporated into investment analysis, capital can be diverted away from investments that would later have yielded significant upside or resilience under emergent market conditions. Yet some uncertainties like policy change could have asymmetric impacts on investment performance and are not amenable to precise quantification.

So how should equity investors differentiate corporate clean energy strategies? Should company boards continue to invest in clean energy projects when the policy context seems so uncertain? What should debt investors be looking for to judge the resilience of energy companies in the face of policy uncertainties? And what can policymakers do to continue to drive investment into clean energy?

The difficulty traditional investment valuation methodologies have in valuing 'optionality' is a further material challenge.

Traditional investment valuation methodologies like Discounted Cash Flow (DCF) analysis are static tools that work best when future market conditions are relatively certain. However, the implications of uncertainties with asymmetric impacts that are particularly difficult to quantify can be difficult to build into such methodologies and they do not place a value on managerial flexibility to adapt to changing

[1] Bloomberg (2011) *Renewable Power Trumps Fossils for First Time as UN Talks Stall*

market conditions over time. Management and investors typically have to apply qualitative analysis to DCF calculations in these circumstances.

At the company level, this flexibility is derived from having the optionality embedded in its portfolio of activities to change direction strategically in response to emergent market conditions; the investment is said to yield ‘optionality’ and because these investments are in assets like capital equipment or non-tradable government permits, rather than financial instruments, they are termed ‘real options’.

Investors and companies already use a range of quantitative and qualitative analyses in their strategic decision-making, but traditional investment valuation methodologies do not, on their own, offer an explicit way to value optionality. This could mean that valuable investment opportunities are overlooked. Enhanced investment valuation methodologies, able to reflect the value of real options in a more explicit way, already exist and are used in both the investment and energy industries (either formally or informally), but their diffusion is still not as wide as is desirable. **Figure A** illustrates the conceptual difference between valuation methodologies that do, and do not, explicitly value optionality and highlights the potential value of that optionality.

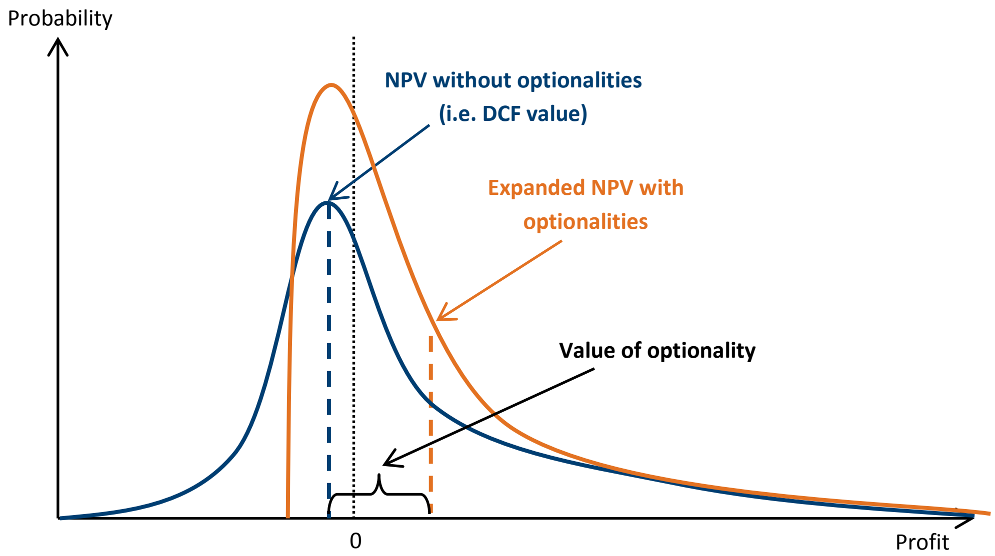

Figure A: Illustrative valuations following DCF and options approaches

An options approach is of particular relevance to the energy sector.

Although an options approach is not specific to the energy sector and it is not designed to deal with completely unforeseen events, there is a strong case to be made for its relevance, even urgency, in the energy sector at the moment; the fundamental need for a long-term transition to a clean energy system is widely accepted, but market and policy uncertainties with asymmetric profiles abound (eg the future price of fossil fuels, the nature and timing of carbon legislation, energy policy) which limits investment. The potential value of real options to deploy clean energy investments is increased by this uncertainty.

This report draws on an evidence base to identify the circumstances in which valuation methodologies enhanced by an options approach are more appropriate.

A group of energy firms is working with banks of the Banking Environment Initiative (BEI) to draw on the banks' roles in capital markets to promote discussion of this topic further. This has been supported by an evidence base compiled independently by the University of Cambridge's Judge Business School.

Our objective is to highlight the circumstances in which traditional investment valuation methodologies understate the potential value of clean energy investments. Three illustrative clean energy investment case studies are presented: investments in Carbon Capture and Storage (CCS) optionality facing uncertainty around the European price for carbon, investments in offshore wind farms facing uncertainty around UK renewables policy and investments in onshore wind farms facing uncertainty around US gas prices. The conclusions drawn are not limited to the technologies or markets that feature in these case studies, indeed a clean energy future requires a broader range of technologies than feature in this report.

These case studies demonstrate that the use of traditional investment valuation methodologies like DCF would be unlikely to see energy sector companies investing in clean energy real options like CCS readiness or pipeline development for offshore and onshore wind farms. These real options are relatively inexpensive and could deliver significant upside potential, or provide resilience, under plausible future market conditions. An options approach provides a valuable perspective beyond DCF.

Table 1 shows the circumstances in which we conclude that an options approach should be incorporated into investment valuation methodologies. These circumstances are present for a range of clean energy technologies, in a range of markets. An options approach should not replace traditional DCF analysis, but is a complementary tool to help improve decision-making under challenging conditions.

Valuation methodology / **Conditions**	**Use traditional valuation methodology (eg DCF)**	**Enhance valuation methodology with an options approach**
Degree and nature of uncertainty around future market conditions	Uncertainty is limited and can be credibly quantified	Uncertainty is significant and cannot be credibly quantified
Shape of probability distribution of future market conditions	Close to symmetric	Asymmetric, with the possibility of high-impact, low-probability events
Management flexibility to change strategy in response to new information	Management flexibility is low; investment problem does not have optionality embedded	Management does have flexibility; investment problem has optionality embedded

Table 1: Conditions under which different approaches to investment valuation are more appropriate

These findings have implications for investors, company boards and policymakers.

Equity investors in energy companies that are making significant, long-term infrastructure investment decisions in the face of significant market and policy uncertainties should be looking for affordable real options in a company's portfolio. In different contexts, such optionality could yield valuable resilience or significant upside, but without them a company is far less likely to be able to respond to changing market conditions. Incorporating an options approach into their own valuations where the conditions detailed in Table 1 prevail should become standard practice.

For **company boards** in the energy sector, actively incorporating an options approach into portfolio strategy-setting processes seems both a prudent risk management approach and a strategy that could potentially secure the company significant value in the future. An options approach should be a useful way to articulate to investors the rationale behind investment strategies.

Providers of corporate and project debt, as well as **ratings agencies**, will be interested in the fact that real options can yield tangible resilience to a company's performance in future market conditions. An options approach therefore presents a meaningful additional way to understand the likely future operating cash flow of a company.

For **industry regulators** and **policymakers**, this analysis shows that focusing on whether the base case Net Present Value (NPV) of a particular clean energy technology is positive is not necessarily the only way to stimulate the desired investment. An options approach should allow those developing real options to justify continuing to do so during discrete periods of unavoidable policy or market uncertainty, thereby mitigating an investment hiatus. However, this does not detract from the importance of giving investors certainty and the more that policy action can remove the most extreme, and most unfavourable, market conditions for clean energy, the more an options approach will favour clean energy investments as well.

Next steps

An options approach is a complementary extension of traditional investment valuation analysis and so does not represent a complicated 'new' approach to investment valuation. Details of the approach adopted for this report are found in the Technical Annex to this report.

Nevertheless, members of the BEI Collaboratory on Clean Energy championed this report because they did not feel that an options approach has been sufficiently widely adopted by investors, companies or policymakers. We hope to stimulate further awareness of, and debate about, the use of an options approach so that the circumstances in which it is appropriate are well understood, commonly identified and it becomes standard practice. This would formalise some existing market practices. Doing so will lead to more robust analysis of the optionality embedded in certain investment opportunities today and therefore better capital allocation decisions in the context of current uncertainty. If the range of that market and policy uncertainty is narrowed to favour a clean energy future more clearly, investment guided by an options approach will follow.

Acronyms

The following acronyms are used in this report:

AEO	Annual Energy Outlook
BEI	Banking Environment Initiative
CAPM	Capital Asset Pricing Model
CCGT	Combined Cycle Gas Turbine
CCR	Carbon Capture Readiness
CCS	Carbon Capture and Storage
DCF	Discounted Cash Flow
EIA	Energy Information Administration (in the United States)
EIS	Environmental Impact Study
eNPV	Expanded Net Present Value
FEED	Front End Engineering and Design
MBTU	One thousand British Thermal Units: a unit of energy
NPV	Net Present Value
PTC	Production Tax Credit
RO	The Renewables Obligation
ROC	Renewables Obligation Certificates

Why might investment valuation methodologies for clean energy need improving?

“Real options approaches provide a useful way…to quantify climate change policy uncertainty. It should be noted that the analysis provided by real options is an extension of the standard NPV analysis. Real options approaches explicitly incorporate individual elements of risk into the cash-flow calculation, taking into account management’s flexibility to adjust their behaviour, as the uncertainties get resolved. This ability to analyse explicitly the effect of a particular source of uncertainty on an investment decision is precisely the reason why a real options approach has been taken in this study.”

***Climate Policy Uncertainty and Investment Risk* © OECD/IEA 2007, pages 30-31**

Capital market participants are questioning whether traditional investment valuation methodologies are sufficient when uncertainty around future market conditions gives rise to asymmetric risk profiles.

Investors constant choose between investment opportunities based on what impact they think uncertain future market conditions will have on risk and return. Rapid technology development and the increased interconnectedness of economic systems are just two factors that have challenged investors recently by heightening, and changing the nature of, the uncertainty around investment risk.

If risks and uncertainties are not appropriately analysed in investment valuations, capital can be diverted away from investments that would later have yielded significant upside or resilience value under emergent market conditions. Yet some uncertainties like policy change could have asymmetric impacts on investment performance and are not amenable to precise quantification, which raises important questions about how they are incorporated into investment decisions.

In scenarios where the distribution of this uncertainty is approximately symmetrical, traditional investment valuation methodologies such as DCF analysis work well.[2] However, the repeated experience of ‘high-impact, low-probability’ events in recent years has left investors acutely aware that extreme events can and do occur, perhaps more frequently than expected, and have material impacts on investment performance. Not only this, but the distribution of possible outcomes has often proven not to be symmetrical, but to be either positively or negatively skewed around the expected mean, or ‘base case’; extremes, though unlikely, may be of a greater magnitude above or below the mean outcome.

In these cases, investment decisions centred on the ‘base case’, or expected normal distribution of outcomes, have proven to be insufficiently robust when market conditions turn out to significantly diverge from the expected base case scenario. Many actors in the capital markets are therefore now questioning whether traditional investment valuation methods are, on their own, adequate tools for robust decision-making when investors are faced with an asymmetrical distribution of outcomes containing high-impact, low-probability events. Indeed, management and investors typically have to apply qualitative analysis to DCF calculations in these circumstances. **Figure 1** illustrates these two scenarios.

[2] Generally, portfolio theory and the Capital Asset Pricing Model (CAPM) are usually based on assumptions such as a normal distribution of asset price movements, constant volatility, and stable correlations between asset classes.

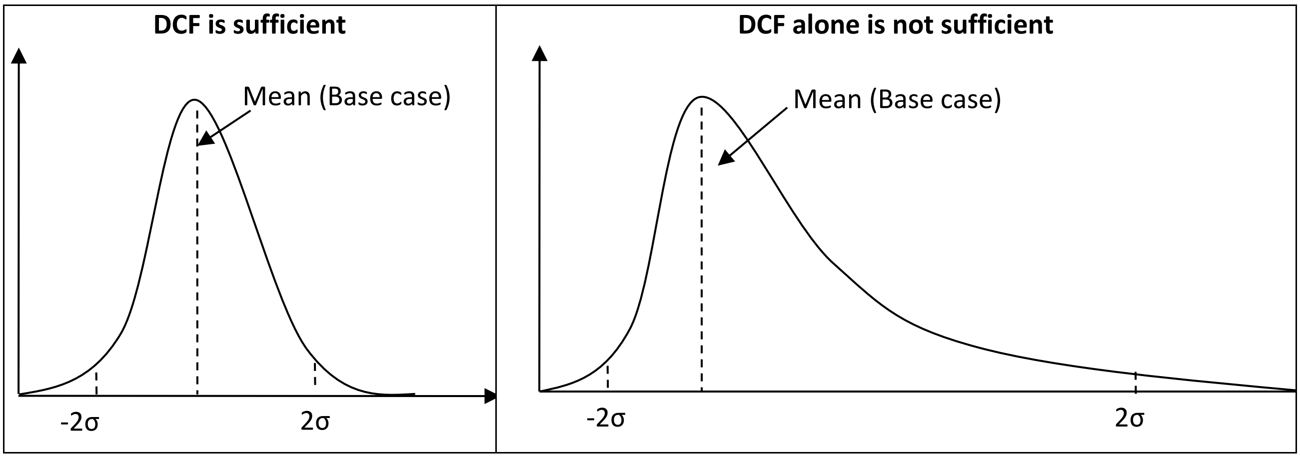

Figure 1: The ability of Discounted Cash Flow (DCF) analysis, on its own, to support robust investment decisions when faced with symmetrical (left panel) and asymmetrical (right panel) probability distributions for future market conditions. NB: Asymmetrical distributions may be negatively or positively skewed.

An options approach is particularly relevant to the energy sector.

It can be argued that investments in the energy sector are characterised by increasing levels of uncertainty as a result of dynamics relating to political issues (eg market liberalisation), policy developments (eg energy and climate change policies), technological advances (eg Carbon Capture and Storage, hydraulic fracturing) and natural catastrophes (eg earthquake).

Some of the most important of these factors clearly have asymmetrical probability distribution profiles. For example, uncertainty around the future carbon price in Europe could be represented by an asymmetric distribution; there is a small but positive probability that the carbon price could be very high at a given point in the future (say, €70/tCO_2 in 2030) but a much smaller probability that the carbon price will be the same order of magnitude lower compared to its current level. With such a distribution, using a mean future carbon price (or the best guess 'base case') for a simple DCF analysis of assets with a long lifecycle could lead to an investment decision that proves not to be robust, because the probabilities of the carbon price moving up or down the same degree are not equal.

The carbon price is not the only risk factor with this type of distribution profile in the energy sector. Fossil fuel price dynamics (eg the Henry Hub spot gas price and the Brent oil price) exhibit similar distribution profiles, in that they are positively skewed. **Figure 2** shows historical data for the price of natural gas in the US, demonstrating this positively skewed distribution. One conclusion that can be drawn from this distribution is that there is asymmetrical upside potential for investments whose performance is positively correlated with gas prices, such as renewables (where the positive correlation is driven by the effect of gas prices on the wholesale electricity price).

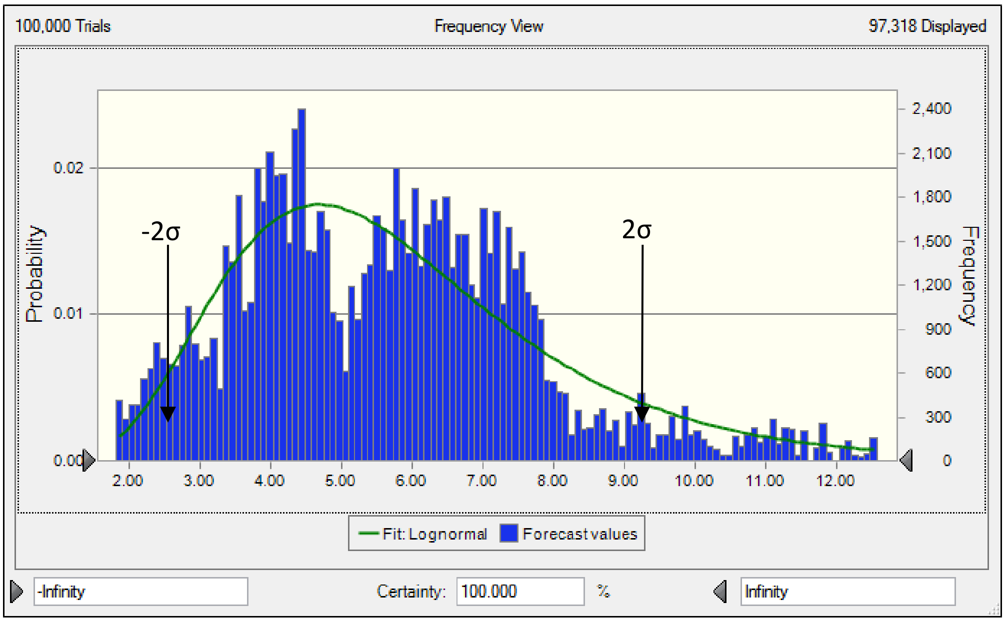

Figure 2: Fitted probability distribution for the natural gas spot price (Henry Hub: 2003–2012), demonstrating marked asymmetry

The combined effect of such uncertainties can substantially alter the value and viability of clean energy investments.

Uncertainty about future market conditions can mean that different clean energy investments might have huge upside as well as downside potential, and can affect their fundamental viability. For example, if the carbon price or other policy support mechanisms are not strong or credible enough, then some clean energy technologies will be 'out of the money'. Yet with sufficient policy support mechanisms in the early stages of development and cost reductions as technologies mature, these same projects could be soon become 'in the money'. The same could be said of clean energy technologies that are viable but not seen as competitive as fossil fuel alternatives, and are therefore not prioritised, but could be more profitable than fossil fuel alternatives under different market conditions.

Failing to incorporate the possibility of significant deviations from the base case can have important implications.

By way of example, the rapid development of unconventional natural gas extraction has had a significant impact on commercial and political expectations about gas market development in the US and internationally. This is evident from annual energy forecasts, produced by the US Energy Information Administration (EIA), which show how expectations of future market conditions turned out to be considerably inaccurate.

Figure 3 shows how the rapid development of unconventional gas resources, which increased the supply of gas in the US, resulted in the 2010 price of natural gas forecast by the US Government in 2009 proving to be an overestimation of more than 50 per cent of the actual price that emerged in 2010. Investment decisions that had used the 2009 forecast price as a mean expected outcome in a traditional DCF valuation without further quantitative or qualitative assessment may now be performing very differently compared to original expectations.

"The financial tool most widely relied on to estimate the value of strategy – discounted cash flow (DCF) valuation – assumes that we will follow a predetermined plan, regardless of how events unfold. A better approach to valuation would incorporate both the uncertainty inherent in business and the active decision making required for a strategy to succeed…Options can deliver that extra insight."

Luerhman, T. A., (1998) Strategy as a Portfolio of Real Options, Harvard Business Review

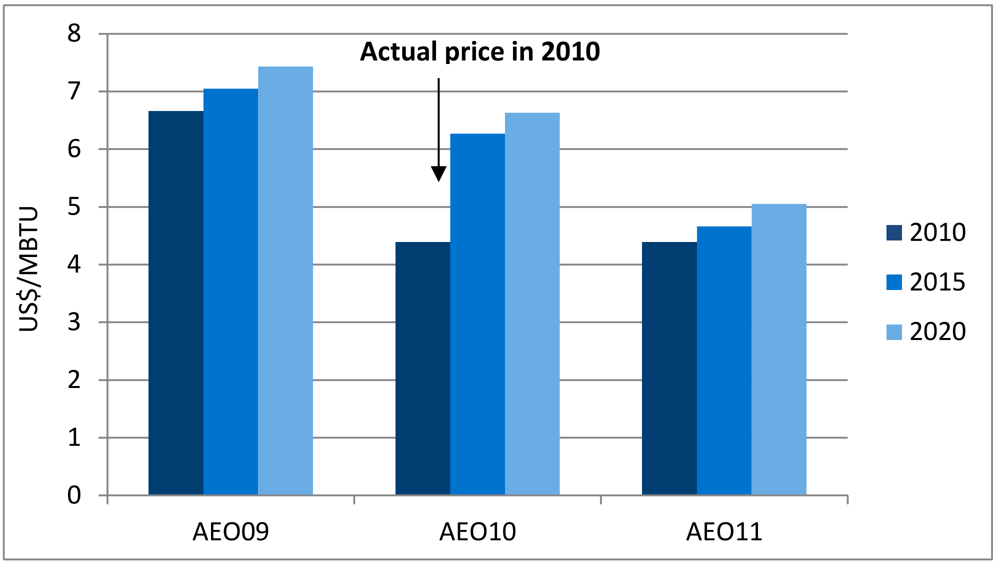

Figure 3: The US Energy Information Administration's projections for US natural gas prices, sourced from its Annual Energy Outlook (AEO) for 2009, 2010 and 2011

Traditional investment valuation methodologies like DCF do not place a value on the ability of an investment to adapt to changing market conditions over its lifetime.

Figure 4 illustrates an investment opportunity that would deliver a company an asymmetrical payoff, depending on future market conditions. If there were ways that the company could open up, or maintain, the real option to deploy this investment opportunity and to then execute it during the lifecycle of the investment, this could be justified on the basis of the value opened up to the company by that optionality.

Without a valuation methodology that can appropriately reflect management's ability to navigate strategically through downside events and to capitalise on the upside potential of such an investment, these investments will remain relatively unattractive under a traditional DCF approach on its own. Indeed, the NPV represented in Figure 4 is only marginally positive, and so a competing investment with a stronger NPV would likely be favoured.

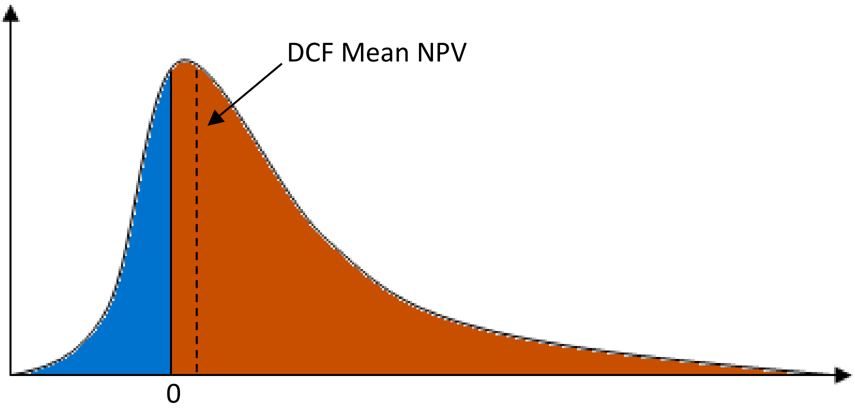

Figure 4: An asymmetric payoff distribution for an investment facing uncertain market conditions; what if management could actively buy real options to take advantage of the upside potential as that uncertainty resolves?

The limited ability of traditional investment valuation methodologies to value 'optionality' could be diverting capital away from clean energy.

The potential value of real options to deploy significant clean energy investments within a company portfolio is increased by the uncertainty discussed, but is not reflected in traditional investment valuation methodologies. The duration and size of the investment lifecycles in the energy sector make this all the more important. Leading firms in the energy sector believe that these factors are playing a substantial role in diverting either mainstream capital or the support of mainstream investors away from clean energy investments that offer strategic optionality to their portfolio, and may risk locking them into fixed assets that are not competitive under future market conditions.

Uncertainties that are not amenable to quantification can all too easily be seen as undermining the value of clean energy investments and this negative view can be reflected in the variables in a traditional investment valuation analysis. In practice, this may mean that company boards, and the investors with equity in those companies, are overlooking investment projects with clean energy real options embedded in them because they do not look attractive under the base case, but could turn out to offer valuable upside or resilience to the company under future market conditions. A book published by the OECD and International Energy Agency in 2007 identifies exactly these limitations in relation to DCF's appropriateness for valuing clean energy investments.[3]

In this context, how should equity investors differentiate corporate clean energy strategies? Should company boards continue to invest in clean energy projects when the policy context seems so uncertain? What should debt investors be looking for to

"Clean energy investments, due to policy uncertainties, are a fitting case for real option type valuation. As highlighted in this report, the asymmetrical payoffs in this sector underline the advantage of using a real options approach in conjunction with DCF approaches (which do not capture asymmetrical outcomes such as policy changes). It is very helpful to have a framework that industry practitioners can agree on and that can be promoted more widely. While the real options approach captures the value from investments better than DCF, the benefits are not just limited to returns (valuation). With sophisticated risk management practices used by major energy players and institutional investors, the benefits also lie in better capturing the risk of investments at the portfolio level. A better management of risk through quantification, control and portfolio diversification would also bring down the barrier against investments in this sector."

Yoko Ohta, Managing Director, Quantitative Solution Research Department, Nomura Securities Co., Ltd.

[3] *Climate Policy Uncertainty and Investment Risk* © OECD/IEA 2007

judge the resilience of energy companies in the face of policy uncertainties? And what can policymakers do to continue to drive investment into clean energy?

The objective of this paper is to highlight the circumstances in which traditional investment valuation methodologies understate the value of optionality embedded in clean energy investments. This will be done through the analysis of three illustrative clean energy investment case studies that oil and gas and electric utility companies might reasonably be considering within their portfolio:

1. **Carbon Capture Readiness** (CCR) for a gas-fired power plant in the UK
2. **Offshore wind farm** development in the UK North Sea
3. **Onshore wind farm** development in the US Midwest

The geographic markets and technologies that the case studies focus on were selected by collaboratory members as being particularly relevant to their businesses, but this does not preclude the paper's conclusions being relevant to other geographies nor to other technologies that play a role in the clean energy mix. Indeed, collaboratory members are clear that a far wider range of technologies than those featured in these case studies are required for a sustainable clean energy mix.

An options approach unpacked

Where uncertainties cannot be credibly quantified, traditional modelling is less appropriate.

"Companies that rely on discounted cash flow analysis for valuing their projects fall inevitably into the trap of underestimating the value of their projects and consequently don't invest enough in uncertain but highly promising opportunities. Real options are a complement to, not a substitute for, discounted cash flow analysis. To pick the best growth projects, managers need to use the two methods in tandem."

Van Putten, A. B. and MacMillan, I. C. (2004) Making Real Options Really Work, Harvard Business Review

Some sources of uncertainty can be quantified, and probabilities of different outcomes applied through detailed modelling. When considering future uncertainty, the use of a discount rate is the explicit treatment of risk through time.

However, a discount rate is not necessarily a helpful consideration of the nature and distribution of future risk, and many material uncertainties are not amenable to quantification at all. This raises important questions about how uncertainty is navigated. This has been the subject of study for a long time; as long ago as 1921, economist Frank Knight drew the distinction between risk – randomness for which the probability can be reasonably quantified – and uncertainty – randomness for which the probability cannot be credibly quantified.

This distinction is embodied in our case studies in the standard way: fuel and power prices as well as technological learning rates are treated as risks, with the probability distributions derived modelled as statistical variation on past observations. Policy decisions such as the level and timing of government support for low-carbon technologies are treated through scenarios, without trying to put a probability against any of the scenarios, since this 'randomness' cannot be credibly quantified.

The conceptual basis of an options approach

There are two simple concepts at the heart of an options approach to investment valuation:

i. Certain investment opportunities buy the investor the ability to strategically expand, contract, abandon or switch the asset during its lifetime. Where doing so would create additional value, the investment opportunity is said to create 'optionality'.

ii. Those managing an investment (eg a Company Board, from a shareholder's perspective) have the ability, and indeed the incentives, to call on such real options to achieve the optimal strategy, as uncertainties are resolved during the lifetime of the asset.

Many different industries already use an options approach, either formally or informally. For example, oil and gas companies use an options approach to justify capital investment in exploration activities; investing capital in concessions buys the company the right to expand production activities, should a new resource be discovered. Even if the vast majority of exploratory drilling activity does not discover mineral resource, the value of that optionality in the successful cases is significant enough to justify the overall capital investment. Pharmaceutical companies can make a similar case for investment in research and development of new drugs.

Key steps in an options approach to investment valuation

"In a capital constrained environment, and with the pressing need to evaluate clean technology power investments in a dynamic regulatory environment, we believe the BEI's real option analysis can be a powerful incremental tool for asset managers, corporates and financial institutions to allocate investments. Real option analysis, when combined with a traditional discounted cash flow, can more accurately capture value creating outcomes that otherwise would be lost - or worse - projects that would not be undertaken."

Tim Whittaker, Head of Equity Research EMEA, Barclays

An options approach to investment valuation comprises a number of key steps, set out in **Figure 5,** but many of these are the same as traditional Discounted Cash Flow (DCF) analysis, so it should not be seen as a separate, or particularly more complicated methodology. Equally, Figure 5 unpacks what is sometimes viewed as an opaque process.

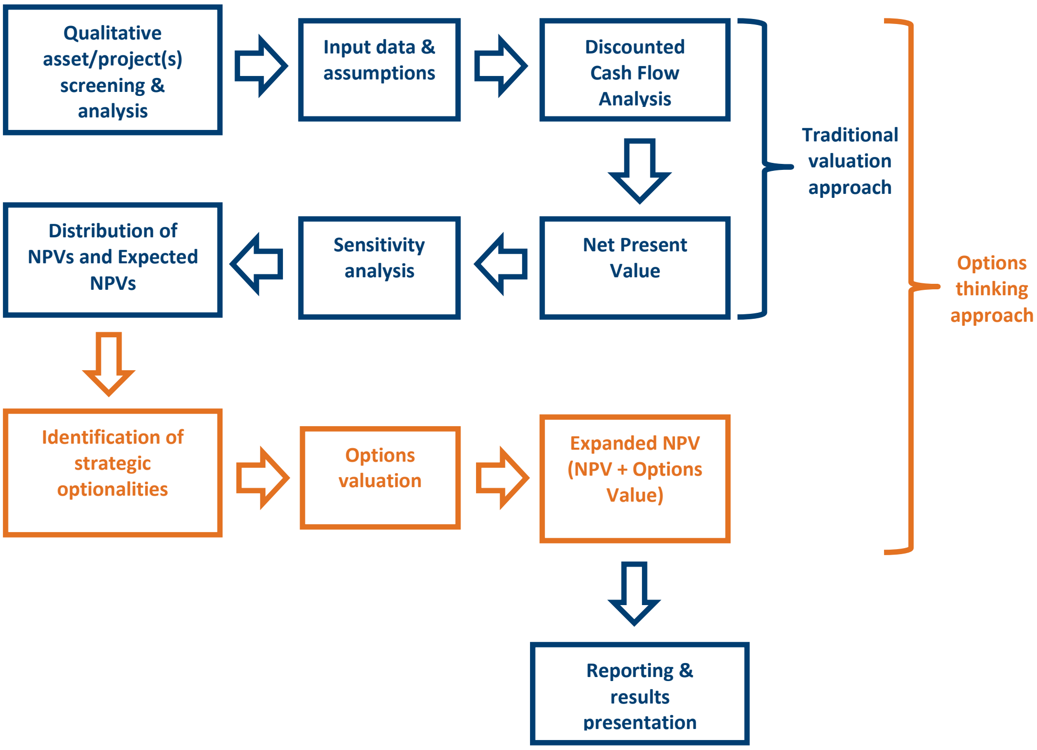

Figure 5: Flow diagram of an options approach to investment valuation, incorporating the same early steps as a Discounted Cash Flow analysis

It is important to understand the core components of DCF analysis first.

1. Traditionally, the first step in investment valuation is qualitative analysis to confirm the viability of the opportunity before further detailed examination is triggered. This qualitative analysis can be used to reduce a range of possibilities to a smaller number of feasible ones that may have good chance of creating value.

2. Input data is then gathered and assumptions about future market conditions relevant to the investment opportunity are made as the basis for Discounted Cash Flow (DCF) analysis.

3. The DCF analysis is, in essence, a cost-benefit analysis where the cost and benefit streams of the investment are projected through the course of its expected lifetime. The cumulative net benefit over the lifetime of the investment is then discounted at the appropriate rate of cost of capital (the discount rate).

4. This gives a proxy for making an investment decision, ie the Net Present Value (NPV) of the investment being considered. Generally, if the NPV is positive, then the investment will likely be made and should create positive value. On the other hand, if the NPV is negative, the investment opportunity will likely be abandoned. If there are two or more competing investment opportunities, the one with the higher NPV will likely be favoured.

5. Since the NPV is highly dependent on assumptions about future market conditions, sensitivity analysis is often performed to reveal the impact of changing future market conditions on the NPV. As the result, a distribution of NPVs is obtained and an expected investment value can be determined.

This process alone is not able to reflect the value of optionality that may be embedded in the investment opportunity. Nor does it allow for the fact that management has the flexibility and incentives to realise the value of real options were certain market conditions to emerge. This is why a traditional DCF valuation risks fundamentally under- or over-estimating the value of the investment where future market conditions are particularly uncertain.

An options approach is able to capture the value of different real options in the context of prevailing uncertainty about future market conditions, coupled with managerial flexibility in choosing optimal strategies as those market conditions evolve and become clearer. It is an enhancement of a DCF analysis as it builds on the same first steps, using the output of the DCF analysis as inputs for the options analysis:

1. Based on analysis of the overall investment problem at the project selection and sensitivity analysis stages of the DCF analysis, optionality embedded in the investment opportunity that could have value is identified. These real options may include, among other things, the ability to expand, contract, abandon or switch the asset during its lifetime.

2. The value of deploying these real options under certain future market conditions can then be calculated, resulting in an expanded NPV (eNPV) which adds the value of the optionality to the standard NPV.

These extra steps are set out in Figure 5.

An options approach can therefore provide additional insights into investment performance beyond traditional investment valuation methodologies. At the very least, it should be seen as a more robust way to perform sensitivity analysis on the results obtained using DCF analysis. At its best, however, it should be seen as a systematic approach to maintaining and increasing investment value where future market conditions are markedly uncertain. The approach adopted to calculate the value of optionality in this report's case studies is set out in the accompanying Technical Annex.

Figure 6 demonstrates the conceptual difference between a traditional investment valuation methodology like DCF and an options approach when facing uncertainties with an asymmetric distribution.

The NPV distribution without considering optionalities is shown by the blue curve, with the expected NPV in the case being slightly negative. This is an investment that would likely not go ahead under traditional DCF-based decision-making.

However, this NPV probability distribution curve does not take into account the fact that, in the course of project implementation, additional information may become available about how some of the uncertainties driving the NPV are being resolved, and that management can respond actively to this new information.

The NPV distribution curve in orange, which incorporates optionality upfront, is truncated on the left, because management is able to exercise its real options to avoid large negative NPV outcomes in response to changing market conditions. Similarly, where real options enable management to take advantage of new upside potential, this NPV curve reflects this. The value of this optionality overall is indicated.

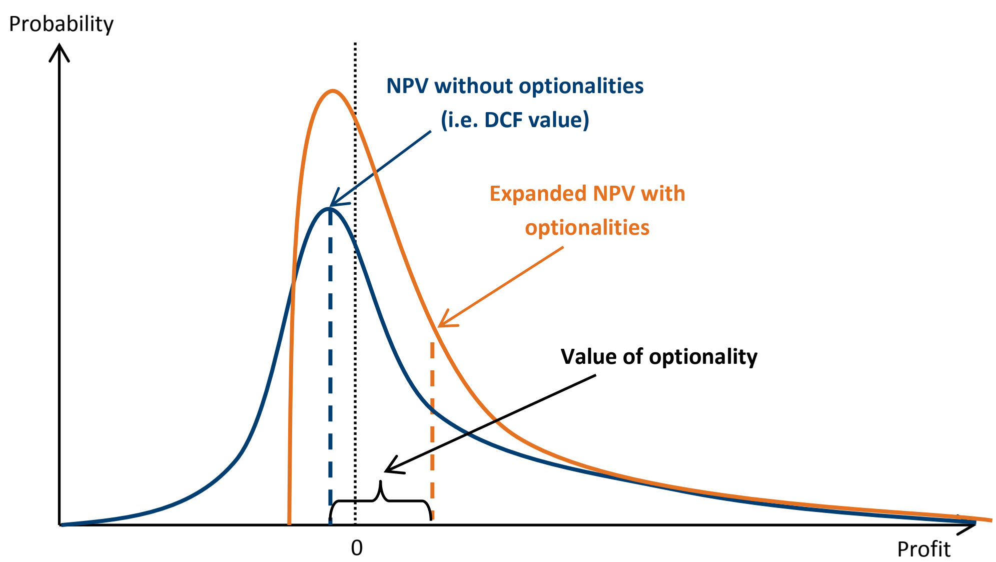

Figure 6: Illustrative valuation following DCF and options approaches

"Northern Trust is pleased to support the Banking Environment Initiative. The work of the BEI aligns with our conservation-minded approach to protecting the environment and delivering innovative solutions to our clients. As investment decisions are based on sound quantitative and qualitative analysis, defining the right framework to evaluate a security, a project or an investment requires evaluating and potentially enhancing the valuation tools available. The collaborative work performed by the BEI and international energy companies is providing an interesting alternative to investment valuation in clean energy. It provides thought leadership for what could become an additional framework to better assess clean energy projects and foster sustainable investments."

Connie Lindsey, Executive Vice President, Corporate Social Responsibility, Northern Trust

Illustrative case studies

These case studies are designed to be illustrative of the central concept of an options approach to investment valuation, and so are intentionally stylised rather than exhaustive valuation models. Data was sourced from publicly available resources to populate the case studies and then reviewed by collaboratory members, before being analysed by the team at the University of Cambridge's Judge Business School.

The geographic markets and technologies that the case studies focus on were selected by collaboratory members as particularly relevant to their businesses, but as mentioned above this does not preclude the paper's conclusions being relevant to other geographies nor to other technologies that play a role in a clean energy mix. Indeed, by including case studies focusing on both UK and US markets, this paper attempts to show that an options approach is not applicable to one market alone.

The input data and market condition scenarios for all of these illustrative case studies can be found in the Technical Annex to this report.

"This report makes a valuable and timely contribution to understanding the complex investment decisions faced by energy companies, and should be considered by company boards, investors, credit rating agencies and policymakers alike. We believe the real options approach warrants a more prominent role in valuation analysis, and is particularly useful when extended from single assets to diversified portfolios."

Alan Brown, Managing Director, Co-Head Global Natural Resources Group, Deutsche Bank

Case Study 1: Investment in Carbon Capture Readiness (CCR) for a gas-fired power plant in the UK

Investment decision

In this case study we assume that a company is considering building a new gas-fired power plant in the UK. As well as uncertainty around future fuel and power price fluctuations, there is significant uncertainty about the carbon price floor, which is seen as central to the business case for Carbon Capture and Storage (CCS), given that the company will be paid for the carbon that it stores. Taking these uncertainties into account, the company faces three alternatives related to its investment decision:

1. **Full CCS:** Invest in a gas-fired power plant with post-combustion Carbon Capture and Storage (CCS) technology from the outset. In this case, the only real option embedded in this opportunity is the operational flexibility of the capture plant. For consistency with the other alternatives, the operator of the power plant can decide whether to turn on or off the capture unit every two years (an interval assumed to be the regular major maintenance cycle for gas-fired power plants).

2. **Capture Ready:** Invest in a Carbon Capture Ready (CCR) gas-fired power plant. Compared to the baseline alternative, CCR would require extra investment in engineering work and design which will enable it to retrofit CCS technology in the future with the most efficient capture technology of the day (eg new solvents). This decision would remove potential for lock-in to an inferior capture process, and so accommodates a degree of learning about carbon capture technology.

Once the CCR power plant has been built, it could be retrofitted with CCS technology every two years.

3. Baseline: Invest in a conventional gas-fired power plant, which only incorporates the extra space required to retrofit a carbon capture module in accordance with UK legislation. This decision could limit the power plant's ability to retrofit with the most efficient capture technology, because without explicitly designing a gas plant to accommodate future technological improvements, it might be impossible to integrate them. As with the other two choices, the carbon capture module could be built onto the existing power plant every two years.

Of the three choices, the CCR gas-fired power plant – the second alternative – should offer the most optionality; in this case the CCR investment buys the operator the real option now to expand full CCS activities at a later date so that:

i. In a high carbon price scenario, the ability to retrofit CCS technology would generate resilience for the company, and

ii. If the company does wish to retrofit, this choice gives it the ability to use the latest, most efficient carbon capture technology and avoid lock-in to inferior technology.

Modelling results

The analysis shows that a relatively modest capital investment in CCR now would indeed serve as a valuable hedge against future market conditions involving a high carbon price (see **Figure 7**). This is because the future installation of a CCS capture module to an existing power plant is enabled by an upfront investment in engineering design studies, space around the core power plant infrastructure, and some additional infrastructure as well. Not having already made these 'readiness' investments either makes it very expensive to retrofit a CCS capture module in the future, or in some cases may remove the possibility altogether.

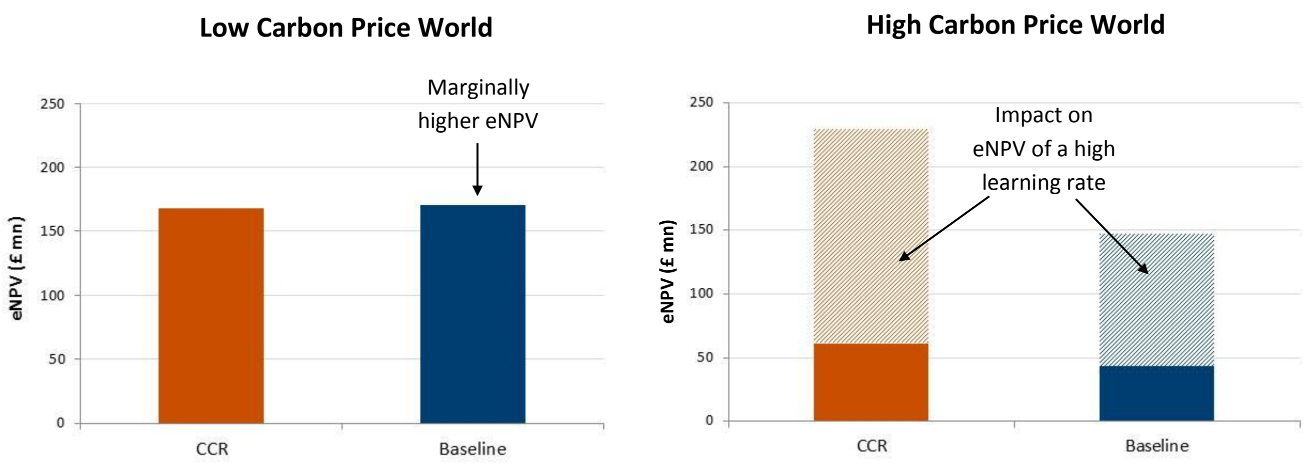

Figure 7: Expanded NPV of an investment in a gas-fired power plant, with and without carbon capture readiness (CCR) under different carbon price scenarios

"In our view, using an options approach is a useful tool when considering the value of an investment scenario with a skewed distribution based on varying assumptions as it avoids placing too much emphasis on static assumptions about the future. This can be of great use to existing or potential shareholders focused on upside potential. Credit analysis focuses on exactly the same concept except with the negative skew of the distribution, rather than the positive, because lenders cannot benefit from unlimited upside. Our credit analysis effectively scores the degree of negative skewness of a distribution of outcomes based on the likely variation in the company's situation. We incorporate both quantitative and qualitative factors (assumptions are a vital ingredient) so credit analysis can also benefit from an options approach that does not over-emphasise static assumptions about the future. Our focus will just be on resilience to downside risk rather than potential to enjoy the upside."

Robin Burnett, Director, Infrastructure Finance Ratings, Standard & Poor's

As shown in Figure 7, in a low carbon price world, the payoff from CCR investment is similar to the payoff from investing in the conventional (baseline) gas-fired power plant. However, in a high carbon price world, when the real option to expand CCS activities is taken the payoff yielded by the CCR optionality is higher than the payoff from investing in a baseline gas plant. Furthermore, if global deployment of the CCS technology is high (ie there is a high learning rate) then the payoff from CCR optionality is significantly higher than the payoff from the investment in the conventional plant.

It is noteworthy that the DCF analysis of the 'Full CCS' choice under both carbon price scenarios does not yield a positive NPV. This is principally because of the structure of the economics of the investment, ie a significant capital investment is required upfront, but the revenue generated by not emitting carbon only gradually increases over a long period of time and these savings are subject to a discount rate. (For simplicity, this is why this choice is not shown in Figure 7.) This shows the importance of both the level and timing of the carbon floor price when viewed from a traditional investment valuation methodology perspective, and underlines the particular challenge of the structure of the economic case for full CCS investment today.

Key implications for the choice of investment valuation methodology

Approaching this investment problem with a traditional investment valuation methodology like DCF alone, investors and company management would likely decline to invest in CCR, because the NPV in the base case looks marginally less attractive than the NPV for the conventional, baseline power plant. In a high carbon price world, this investment decision turns out to perform poorly compared to alternatives.

However, an options approach reveals that the value of investing in the real option generated by CCR today could yield significant resilience under future market conditions that put a high price on carbon. This optionality is restricted in the future if the decision is made to only invest in a conventional power plant.

Given that the lifecycle of the asset will span many decades, it is arguably not credible to quantify the uncertainty around the price of carbon over such a timescale; an extremely high carbon price is a conceivable high-impact, low-probability event. In this investment problem, management clearly could have the ability to call on the 'readiness' real option during the asset's lifecycle, so the relatively modest capital investment in CCR seems justified when viewed through an options approach.

Case Study 2: Investment in offshore wind farm development in the UK's North Sea

Investment decision

In this case study we assume that an electric utility with a mixed generation portfolio which includes conventional fossil fuels is considering investing in offshore wind farm development in the UK's North Sea.

As well as the uncertainties around future power prices and the reliability of the wind resource, there is a key uncertainty about the continuation and credibility of the government support regime provided through the Renewables Obligation (RO), which is seen as central to the viability of offshore wind at present.

The RO is the Government's main support mechanism for encouraging investment in new renewable electricity generation capacity in the UK. Electricity suppliers are obliged to source a steadily increasing proportion of electricity from eligible renewable sources, evidenced through the purchasing and subsequent surrendering of Renewables Obligation Certificates (ROCs), or pay a 'buy out' price for any shortfall. The buy out funds are recycled back to those suppliers who did surrender ROCs, thereby increasing the value of the certificates.

Originally, all renewable generation earned 1 ROC for each MWh of electricity generated, which favoured more established technologies. In 2009, the Government introduced a 'banding' system so that different technologies would earn a different number of ROCs depending on the technology employed. Since then, there have been a number of rolling reviews of the number of ROCs awarded to different technologies (so-called 'rebanding'), which has introduced uncertainty as to the level and length of Government support. Rebanding is resolved periodically for a given time horizon.

In the context of the significant policy uncertainty around the ROC banding, the electric utility faces two alternatives if it wants to look at offshore wind farm development:

1. **Development:** Invest in the development phase of the offshore wind farm as a discrete investment. This involves investing in the pre-FEED (Front End Engineering and Design) study, the Environmental Impact Study (EIS), gathering data about the wind resource at the chosen location and obtaining government approvals and licenses.

2. **Full construction:** Commit to investment in the full construction of the offshore wind farm. This decision would include, and be contingent on the outcome of, investment in the development phase but would see capital committed to the full construction of the asset upfront.

The offshore wind farm investment problem is structured here assuming that some large-scale wind farms do not make it through the development phase to full construction, due to emergent market and policy dynamics such as power prices, technology innovation and the level of government support through the RO (ie the number of ROCs to be awarded to offshore wind farm development). It is also assumed that, during the development phase, the company is able to learn more about the wind resource at the chosen location, as well as about how other market conditions are emerging.

Of the two choices, the choice to invest in the development phase as a discrete investment acknowledges that at the conclusion of this investment, management has the real option to continue investing in developing the asset, or not, in response to market conditions. Thus, there is inherent optionality in the choice to invest in the development phase as a discrete investment; the development phase investment can be seen as a real option.

Modelling results

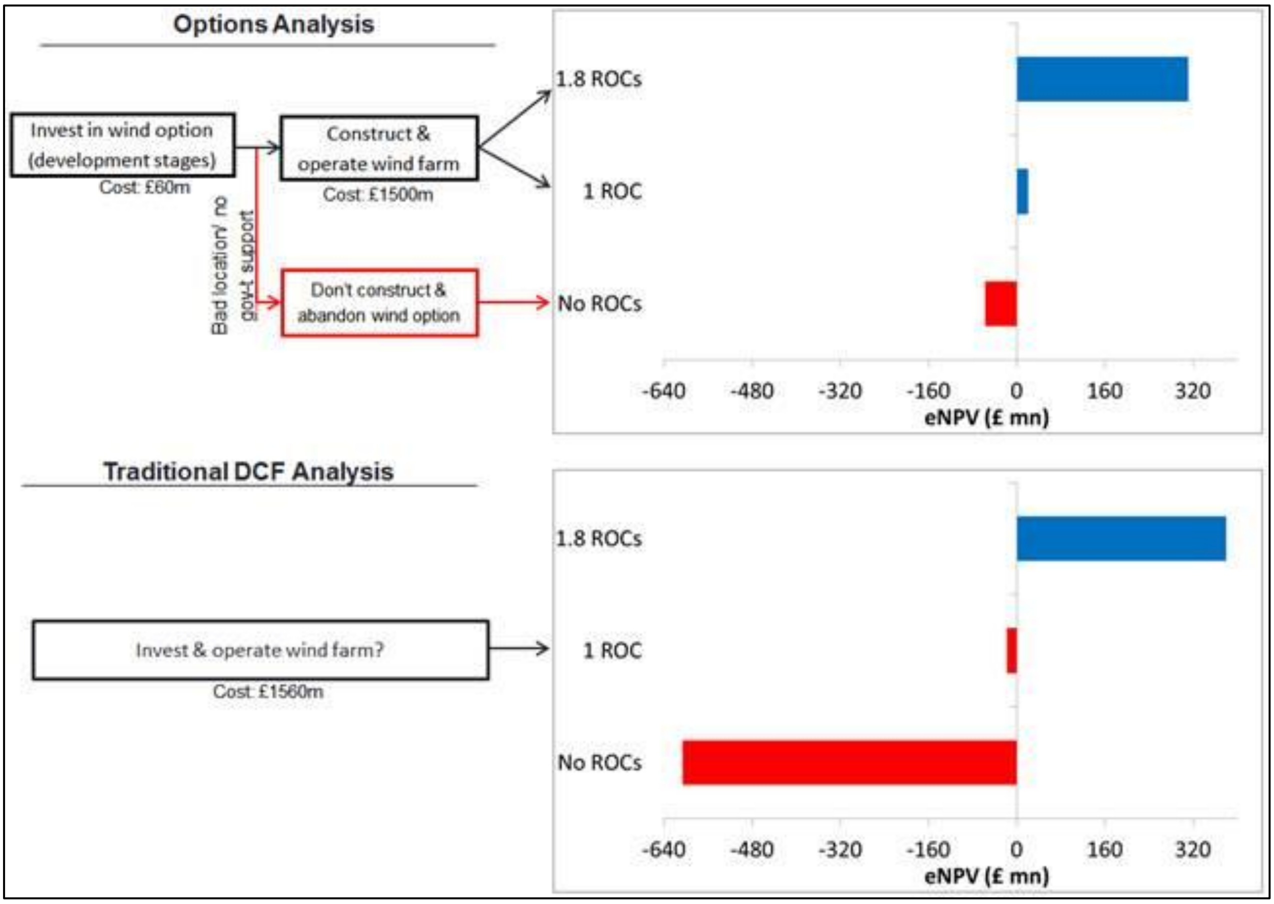

Figure 8: Traditional valuation analysis vs. an options approach applied to offshore wind farm investment in the UK

"In a world currently characterised by political and economic uncertainty it takes real leadership to look over the parapet and see what else is on the horizon. Climate change is one such challenge we all have to face and it presents a host of 'inevitable surprises' and real business issues. Westpac accepts the scientific consensus that climate change is real and is happening, and has led several initiatives over the years to support the transition to a low carbon economy. The collaboration of leaders from the fields of finance, business and academia under the umbrella of BEI, is one such tangible attempt to find practical solutions and encourage more investment in clean technology. The concept of 'real options value' provides an innovative way to integrate the risks, and opportunities, in relation to the uncertainties faced by the long term investment decisions in clean technology. Westpac, with its long tradition and acknowledged leadership in sustainability, is proud to be part of the BEI and the Collaboratory on Clean Energy."

Martin Hancock, Chief Operating Officer, Westpac Institutional Bank

As shown in **Figure 8,** the analysis shows that breaking the investment problem down and treating the development phase as a discrete investment enables the company to minimise its downside risk in the face of material market uncertainty; if the development phase concludes and the market conditions do not look favourable – if for instance a 'no ROC' world is by then looking more likely – management can take the decision to abandon the relatively modest development phase investment. If the decision to commit to full construction had been taken at the outset under a traditional investment valuation approach and the 'no ROC' world emerged, then the loss would be significant.

However, if the company invests in the development phase and during that time – which can be several years – the Government's latest review of the ROC regime concludes that the new ROC banding regime will award 1 or 1.8 ROCs to offshore wind, the ability to quickly move into full construction would yield upside value (indeed, quite significant upside in the 1.8 ROC scenario). Further, there is additional value to having invested in the development phase, through the learning about the wind resource at particular locations that is gathered during that process, which allows better locations to be prioritised. This explains some of the difference between the eNPV under the two approaches, hence for example the eNPV in the '1 ROC' scenario shifting from negative under the traditional DCF analysis to positive under the options analysis approach. Note that these case studies are illustrative of the concept of an options approach and so conclusions about the commercial viability of specific ROC bandings cannot be drawn.

This case study analysis does however suggest that electric utilities could justify investment in the development phase of offshore wind farms on the basis that the real option to construct the full wind farm could yield significant upside value under plausible future ROC banding regimes, and that the development phase investment is a relatively modest investment compared to the overall construction cost. With respect to learning about the wind resource, the value of this optionality is best enjoyed at the portfolio level, implying that a pipeline of offshore wind farm development is appropriate.

It should also be noted that the expanded NPV (eNPV) in the 1.8 ROC scenario is lower if the company decides to invest first in the development phase and then invest in full construction, primarily because the higher the level of Government support, the lower the volatility of the eNPV. With the knowledge at the conclusion of the development phase that there is likely to be lower volatility around the eNPV, it is not surprising that the value of the optionality is consequently lower as well. This is compared to the higher level of volatility that has to be assumed around different ROC scenarios if the investment problem is considered solely on the basis of whether to commit to full construction at the outset or not.

Key implications for the choice of investment valuation methodology

Approaching this investment problem with a traditional investment valuation methodology like DCF alone, a binary decision about whether or not to go ahead with the full construction of the wind farm would likely be all that would be considered. If this were the case, and decision-makers were faced with uncertainty around the future ROC regime which did not appear amenable to quantification, the '1 ROC' scenario has to be assumed to be equally as possible as any of the other scenarios. This would produce a base case NPV that was negative, and the investment would be highly unlikely to go ahead at all.

Using an options approach, the value of the new knowledge about market conditions available to the company at the conclusion of the development phase, and of management's ability to change strategy accordingly is explicitly reflected in the investment valuation. From a project-specific point of view, the most striking conclusion is that an options approach therefore recognises managerial flexibility that could be exercised to reduce the cost of abandoning the investment should the 'no ROC' scenario emerge. If an options approach had been applied across a portfolio of investments, this reduced downside is set in the context of enabling the company to position itself to enjoy the potential for significant positive NPV for the investments should the '1 ROC' or '1.8 ROC' scenario emerge.

The decision would therefore likely be taken to invest in the development phase as a discrete investment that is relatively modest compared to the overall cost of full construction. This would give the company both the optionality to protect itself from significant downside risk, and to act quickly to capture potentially significant upside, depending on emergent market conditions. Without having invested in the development phase, this upside potential is less, or even not, available to the company because of the time required to conclude the development phase.

For clarity, once the development phase has been concluded, the optionality embedded in the development phase expires. The decision on whether to proceed with or abandon full construction is therefore best taken using a traditional DCF approach.

Case Study 3: Investment in onshore wind farm development in the US Midwest

“Energy policy in countries around the world is in flux, shaped by the politics of natural disasters (nuclear, following Japan’s tsunami), carbon legislation (coal), extraction (shale gas), supply (oil) and technological advancements (wind, solar). Lloyds Bank's core mission is to bring value to its customers - through the BEI we have enjoyed dialogue and collaboration with our customers and shared our perspective on the clean energy debate through our substantial experience in financing Renewable and Conventional power projects. We hope that an options-based approach will assist our customers in making their important high value investment decisions and in doing so build sustainable businesses that prosper through the cycle, drive the economy and provide mutual business opportunities for years to come.”

Dan Carr, Senior Vice President, Project Finance, Lloyds Banking Group

Investment decision

In this case study we assume that an electric utility with a mixed generation portfolio which includes conventional fossil fuels is considering investing in onshore wind farm development in the US Midwest.

In the US, relatively expensive gas prices and government support for renewable energy through such mechanisms as the Production Tax Credit (PTC) have helped to deploy substantial onshore wind power generation. Onshore wind technology is a more mature technology compared to offshore wind and for locations with good wind resource, onshore wind generation has been able to compete with conventional fossil-fuel power generation.

However, of late, the absence of a clear and stable government policy for extending the PTC has created a boom and bust cycle of investment in onshore wind power generation. The value of onshore wind generation has been even more markedly challenged by the rapid development of unconventional gas resources which has over-flooded the US market with cheap gas, thereby threatening to price wind generation out of the market because of the price-setting impact of gas prices on wholesale electricity prices. There remains significant uncertainty about whether this low gas price can be sustained, not least because of the threat of stricter regulation on unconventional gas extraction.

In the context of the significant market uncertainty around the future gas price, the electric utility faces two alternatives if it wants to look at onshore wind farm development:

1. **Development:** Invest in the development phase of the onshore wind farm as a discrete investment. This involves investing in a pre-screening study, wind resource analysis at the chosen location and an Environmental Impact Study (EIS), and obtaining government approvals and licenses.

2. **Full construction:** Commit to investment in the full construction of the onshore wind farm. This decision would include, and be contingent on the outcome of, investment in the development phase, but would see capital committed to the full construction of the asset upfront.

The onshore wind farm investment problem is again structured here assuming that some large-scale wind farms do not make it through the development phase to full construction, due to emergent market and policy dynamics as well as the learning about the precise nature of the wind resource that is only achieved in the development phase.

Thus, the optionality considered here features at the end of the development phase of the onshore wind farm, at which point the electric utility has the ability to expand its investment into full construction, or abandon the particular project. This decision would be influenced by the company's new information about the wind resource at the location in question as well as about power market developments, driven largely by the gas price.

Modelling results

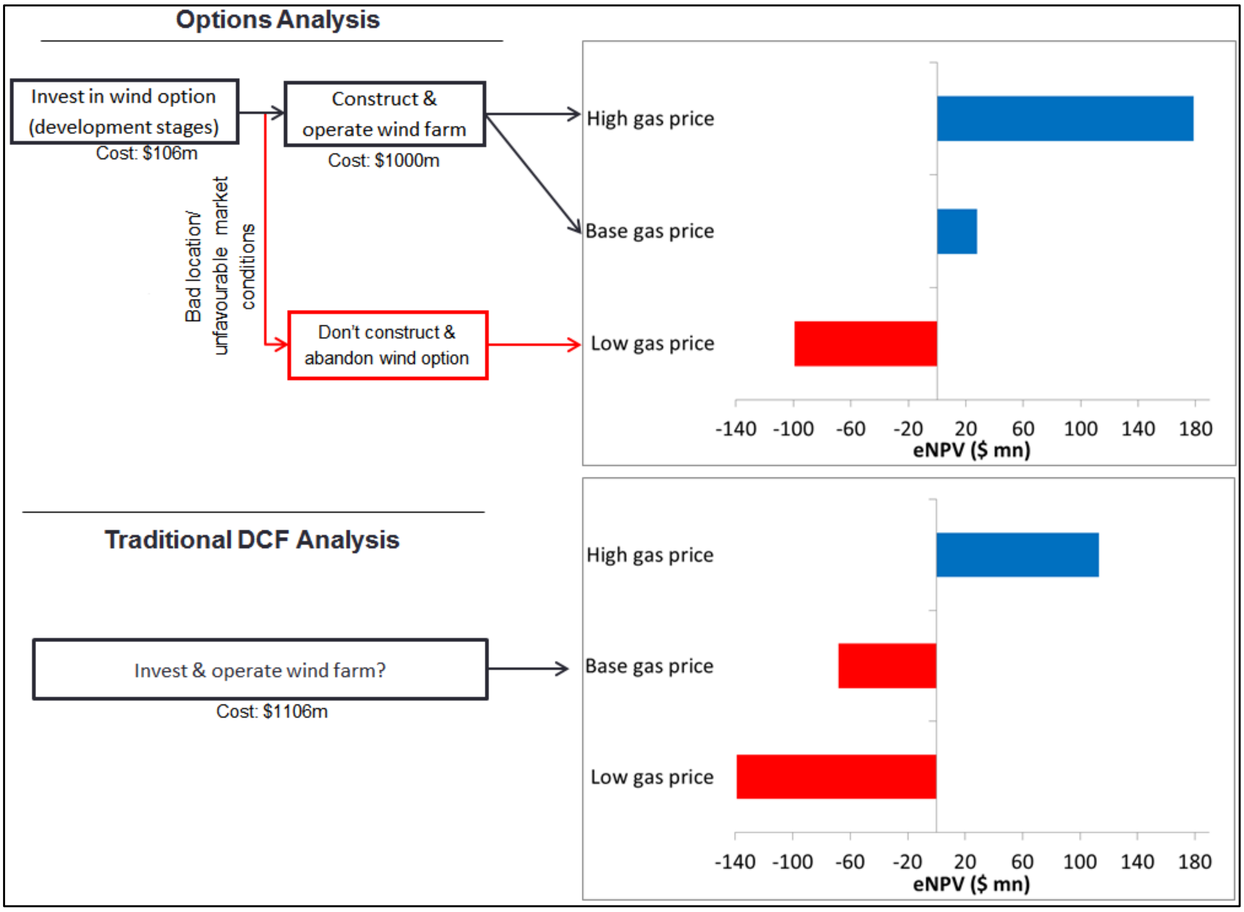

Figure 9: Traditional valuation analysis vs. options approach applied to onshore wind farm investment in the US

This case study analysis focuses on the future performance of the onshore wind farm under consideration, against an uncertain backdrop of wholesale electricity prices driven by related uncertainty in the future gas price. The high gas price scenario assumes that there is stricter regulation of unconventional gas extraction, which drives prices up. The base gas price scenario is based on current market conditions, and the low gas price scenario assumes that further unconventional gas extraction is permitted, driving the price of gas down further. Throughout, it is assumed that the PTC regime is not extended.

As shown in **Figure 9,** the analysis shows that breaking the investment problem down and treating the development phase as a discrete investment again enables the company to reduce its downside risk as well as open it to the potential of significant upside, even in market conditions different from those considered in the offshore wind case in the UK.

In the case of onshore wind in the US, if at the conclusion of the development phase gas prices are either within the base gas price scenario or are higher following stricter regulation of unconventional gas, the benefit of learning about the wind resource during the development phase means that with the most favourable locations, the NPV for full construction is positive. It is worth noting that sensitivity analysis using different levels of PTCs and different qualities of wind resource did not affect this overall conclusion, ie the NPV for the onshore wind farm was still positive in the base gas price scenario. This reflects the maturity of the technology and also points to the benefit of an electric utility having a portfolio of development opportunities, so that the best locations can be prioritised.

This analysis also suggest that in the US, onshore wind can serve as a valuable hedge against high gas prices for an electric utility with a mixed portfolio, given the positive correlation between the performance of the wind asset and the gas price. This positive correlation is driven by the wholesale electricity price-setting role of gas in the US market.

This case study therefore suggests that electric utilities could justify investment in the development phase of onshore wind farms on the basis that the real option to construct the full wind farm could yield significant upside in a world of high gas prices, could offer a robust upside in a base gas price world with the benefit of learning more about the wind resource at chosen locations, and could limit the downside if a low gas price world emerges and renders onshore wind not viable. As in the offshore wind case, with respect to learning about the wind resource, the value of this optionality is best enjoyed at the portfolio level, implying that a pipeline of onshore wind farm development is appropriate.

Key implications for the choice of investment valuation methodology

Approaching this investment problem with a traditional investment valuation methodology like DCF alone, the value of managerial flexibility to benefit from learning during the development phase about the quality of the wind resource at a given location, and to couple that information with new knowledge about the important emergent context of the price of gas, is overlooked. As a result, taking the base gas price scenario, a negative NPV is shown and, again assuming a binary decision about whether or not to go ahead with full construction of the wind farm, this investment would most likely not be approved.

Given the level of debate and uncertainty about the future price of gas in the US, the fact that an options approach yields a robust, positive NPV for the full construction of the onshore wind farm even in a base case gas price scenario may lead to a materially different investment decision. If this approach was applied across a portfolio to take advantage of the accumulated benefits of investing in developing wind farms at a variety

"Governments have ambitions to limit warming to 2°C, but have not implemented regulations to achieve this goal, leaving business to deal with the policy uncertainty. Our Low Carbon Economy Index shows that even doubling our current annual rates of decarbonisation globally every year to 2050, would still lead to 6°C of warming, making the 2°C target appear highly unrealistic. The new reality for business is a much more challenging future in terms of planning, financing and predictability. Our analysis shows that business needs to plan for a warmer world as well as anticipate disruptive policy interventions. Business has to learn to live with this uncertainty and have the tools to continue to invest. Real options analysis provides the tools for business to do this."

Jonathan Grant, Director, PwC

of different locations, capital would be allocated in such a way as to position the company to reduce its downside and take advantage of the relative upside potential of onshore wind as it relates to the price of gas. Without having invested in these development real options, the company will be less agile in responding to the relative profitability of onshore wind in the scenario that government action restricts unconventional gas extraction.

Again, it should be emphasised that once the development phase is concluded and a decision made about whether to expand or abandon that real option, that optionality expires and the decision to proceed is best informed by traditional DCF.

Conclusions

This paper has shown that there are significant uncertainties affecting the performance, or even viability, of clean energy investments that do not lend themselves to quantification. Further, these uncertainties are often asymmetric in nature, holding the possibility of high-impact, low-probability events. It has been shown that various clean energy technologies contain with them intrinsic choices to make investments today that are relatively inexpensive compared to the overall investment, but that would serve as real options to expand or abandon that investment in the future, as market uncertainties are resolved.

The illustrative case studies have demonstrated the value of this optionality under plausible future market conditions, in either opening up the potential for meaningful upside, or providing important resilience to the company.

The case study analysis has also shown that traditional investment methodologies like DCF would likely not have identified, and certainly not prioritised, the investment decisions that have optionality embedded within them, meaning that the companies making those investment decisions would not have been in a position to enjoy that potential upside or resilience. At the very least, they could only have enjoyed these benefits at a greater future cost.

Key conclusions for equity investors

Equity investors in energy companies that are making significant, long-term infrastructure investment decisions in the face of significant market and policy uncertainties should be looking for affordable real options in a company's portfolio. In different contexts, such real options could yield valuable resilience or significant upside, but without them a company is far less likely to be able to respond to changing market conditions. Incorporating an options approach into their own valuations where the conditions detailed in Table 1 prevail should become standard practice.

Key conclusions for company boards

For company boards in the energy sector, actively incorporating an options approach into portfolio strategy-setting processes seems both a prudent risk management approach and a strategy that could potentially secure the company significant value in the future. An options approach should be a useful way to articulate to investors the rationale behind investment strategies.

Key conclusions for debt investors and ratings agencies

Providers of corporate and project debt, as well as ratings agencies, will be interested in the fact that real options can yield tangible resilience to a company's performance in future market conditions. An options approach therefore presents a powerful, additional way to understand the likely future operating cash flow of a company.

Key conclusions for policymakers

For **industry regulators** and **policymakers**, this analysis shows that focusing on whether the base case Net Present Value (NPV) of a particular clean energy technology is positive is not necessarily the only way to stimulate the desired investment. An options approach should allow those developing real options to justify continuing to do so during discrete periods of unavoidable policy or market uncertainty, thereby mitigating an investment hiatus. However, this does not detract from the importance of giving investors certainty and the more that policy action can remove the most extreme, and most unfavourable, market conditions for clean energy, the more an options approach will favour clean energy investments as well.

Next steps

It has been shown that an options approach is a complementary extension of traditional investment valuation analysis and so does not represent a complicated 'new' approach to investment valuation. Details of the approach adopted for this report are found in the Technical Annex to this report.

Nevertheless, members of the BEI Collaboratory on Clean Energy championed this report because they did not feel that an options approach has been sufficiently widely adopted by investors, companies or policymakers. We hope to stimulate further awareness of, and debate about, the use of an options approach so that the circumstances in which it is appropriate are well understood, commonly identified and it becomes standard practice. This would formalise some existing market practices. Doing so will lead to more robust analysis of the optionality embedded in certain investment opportunities and therefore better capital allocation decisions in the context of current uncertainty. If the range of that market and policy uncertainty is narrowed to more clearly favour a clean energy future, investment following an options approach will follow.

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