UNIVERSITY OF CAMBRIDGE
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INVESTMENT DECISIONS UNDER CLIMATE POLICY UNCERTAINTY

BASED ON WORKSHOP DISCUSSIONS AND INTERVIEWS WITH SECTOR PARTICIPANTS

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INVESTMENT DECISIONS UNDER CLIMATE POLICY UNCERTAINTY

Based on workshop discussions and interviews with sector participants

1 The qualitative argument

Dealing with price uncertainty is nothing new for investors in energy-related markets. The impact of the additional uncertainty relating to CO_2 prices and allocation methodologies may first appear to be limited. However, there are two aspects to be considered:

First, emissions trading and climate policy in the wider context are subject to *regulatory* uncertainty – at what level of stringency and under what rules CO_2 markets and other policy instruments are implemented:

- By its very nature, regulatory uncertainty is driven by rather soft factors relating to future decisions by policy makers. These are difficult to quantify, therefore it is difficult to attribute probabilities to different scenarios.
- Climate policy has international objectives and involves activities by many nations. The evolution of such non-corporative games is particularly difficult to predict as frequently multiple outcomes are feasible (see presentation Smeers).
- If climate policy is implemented only in part of the world, then leakage can influence certain sub-sectors. Again, these distortions are difficult to quantify and predict and puts additional pressure on policy makers.
- The additional uncertainty complicates investment choices or creates additional costs for capital.

Second, where a trading framework has been clearly established – e.g. within the ETS after the national allocation plans have been decided upon – price formation is subject to market forces, and thus much of the price uncertainty is typical market uncertainty. While price uncertainty is typical to many markets, we acknowledge that the CO_2 price uncertainty has some special features:

- There are no natural lower bounds for CO_2 prices, in contrast to most commodities where marginal production costs set 'natural price floors'.
- The lack of a long-term price history implies that there is no 'objective' approximation for the future price formation. There is not even a long-term supply and demand balance as was available for many markets formed at deregulation to approximation of history of shadow prices.
- Some industries and their share-holders have become accustomed to live with e.g. oil price risk. (i) Shareholders of oil companies might benefit from the exposure to oil prices and use it to hedge other positions in their portfolio. CO_2 price uncertainty is another dimension of uncertainty that is difficult to quantify and use as hedge in a portfolio. As a result investors perceive it as risk for operating costs. (ii) The energy business exhibits large scale vertical integration – to some extent as a means to protects against price and margin fluctuation. It will at least require a significant transition period to adjust industry structures such that the integration protects against CO_2 price uncertainties.

Even where prices formation occurs in markets, there is a long history and ongoing efforts of government intervention, e.g. by provision of export credit guarantees or strategic oil reserves. Projects like commodity price stabilisation have also been very popular particularly where they intended to reduce risks for small farmers (Newbery and Stiglitz, 1981). However, they frequently failed because (i) storage costs are high (ii) coordination among multiple countries is difficult. Some aspects of ‘commodity price stabilisation might be easier to implement for CO_2. For example, price floors for CO_2 allowances usually do not create real costs for governments where allowances are auctioned but could even stabilise revenue streams.[2]

2 Perspectives by different decision makers

We started the workshop with what we perceived to be a broad question: how do investors' perceive the uncertainty about CO_2 policy and prices and how does this uncertainty affect their investment choices? The subsequent discussions revealed that different sectors and organisations differ in their response to the uncertainty for historic, institutional and technological reasons (see also Hamilton and Kenber 2006).

In a very simplified picture we could describe four sets of investors:

- **Oil majors** are used to carrying out investments with long horizons against internally developed scenarios of the global market and policy evolution. The stringency of current policies is important political signal, as they are an indicator for the credibility of future targets. From long-term targets and perspectives the role of different technologies or the implied long-term carbon prices is deduced. Investment projects are then benchmarked against projects of other business units and companies to ensure a competitive advantage and profitability.
  Current spot and forward prices are less importance for long-term investment decisions of oil majors, and more relevant for risk and uncertainty analysis to determine and manage exposure to upside and downside risks. For example, the break even point required for new investment still is in the order of 25 \$/bbl despite oil price levels and forecasts exceeding the 50\$/bbl range. Even reasonable carbon prices are unlikely to have a measurable impact on oil demand due to inelastic demand and already high taxes particularly in the EU. Transportation sector specific policies are likely to be more relevant.

[2] If the allowance price falls to zero while CO_2 allowances are auctioned, then government revenues also vanish. With a reserve price in the auction a somewhat smaller supply is auctioned at a positive price.

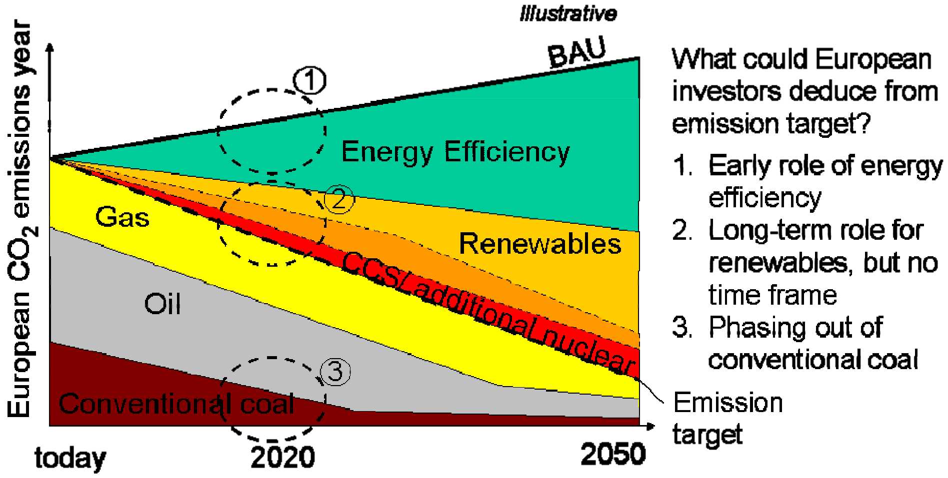

Figure 1 Using long-term emission targets to assess role of different technologies over next decades.[3]

- **Technology developers and manufacturers** are always eager to take forward their new technology – but to obtain funding and in kind resources they have to show to third parties credible scenarios for the role of their technology. They cannot use the approach of oil-majors to deduce the future market share of their technology from future emission targets, because (i) internally developed scenarios illustrating the role of a certain technology are not credible to third parties (ii) many pathways lead to long-term emission targets, and the time when for example renewables start to make significant contributions to the energy mix can vary significantly between feasible scenarios. Explicit renewable targets, e.g. for 2020, can provide reassurance that policies will be in place to address technical and administrative barriers for the deployment of renewables. They can contribute to confidence that there will be a market for successful technologies in the time frame required by investors.

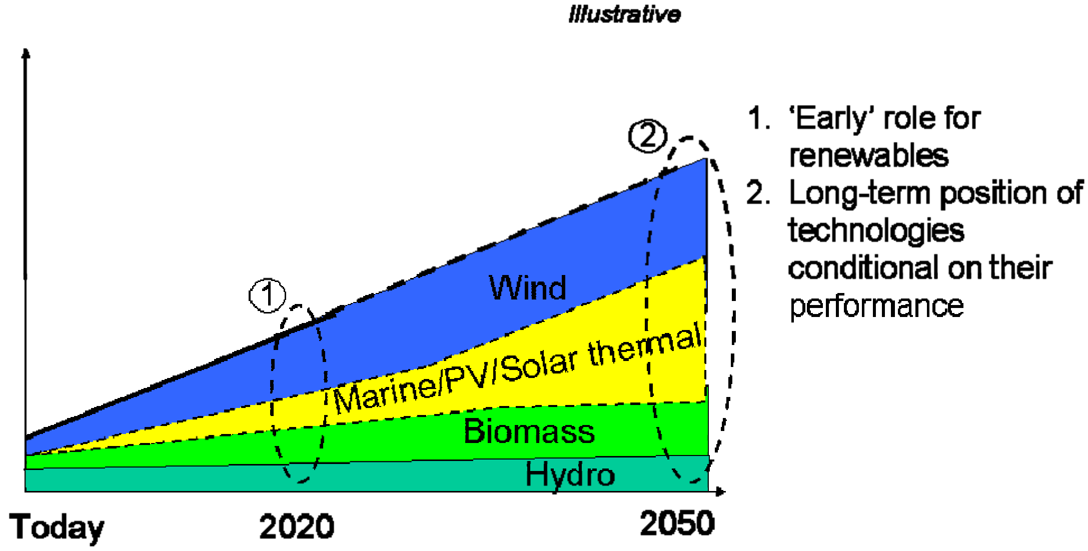

Figure 2 Using renewable targets to assess role different renewable technologies can play in portfolio

- **Utility companies** have experienced over decades how regulatory and policy choices determine investment outcomes. The differing market shares in nuclear across countries illustrates that such policy preferences are difficult to explain using simple economic

[3] Assuming the energy provided from existing nuclear stays constant.

reasoning. Utilities are therefore mainly guided by current policy frameworks, like ETS, when assessing investment choices. Current prices, forward prices, and existing policies are dominant drivers for investment choices and only very credible commitments to changes of these policies will affect decisions.[4] In the absence of any such strong guidance, some utility companies might continue with traditional investment approaches, mainly focusing on diversification between coal and gas. This is a particularly the case where stated policy goals are inconsistent - like reducing import dependency (more domestic coal) and reducing emissions (more imported gas).

- **Banking services** provide debt to finance investments across different sectors. They have to implement internal control mechanisms to ensure individual business units do not take excessive risks. Thus they cannot allow business units to engage in speculation about future evolution of markets and policies. They prefer to use data on historic performance of technologies and sectors to assess investment risks. In the absence of historic data they accept policies if they are sufficient simple, transparent and credible. Investments that are projected financed including a significant debt share are thus subject to the evaluation of banks.

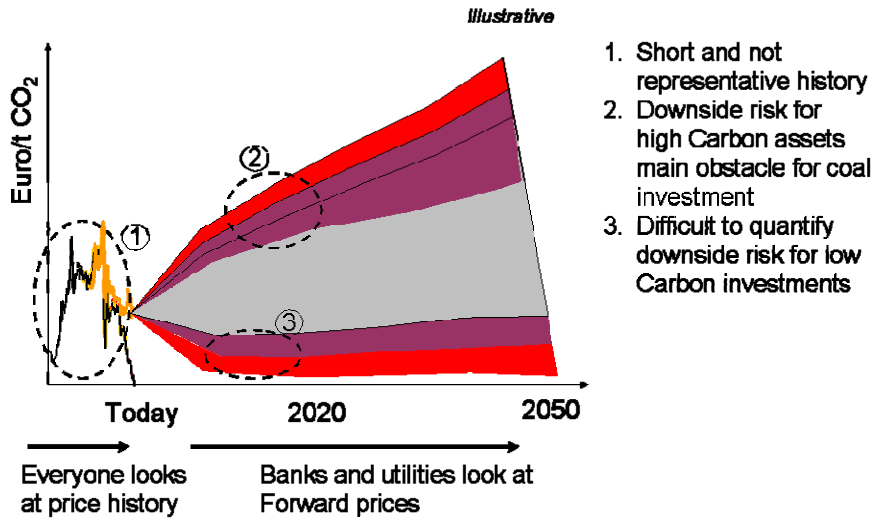

Figure 3 CO_2 price projections and their impact for different agents involved in investment decisions

Table 1illustrates which uncertainties 19 interviewed investors across various sectors from various sectors consider to be important in their decision process.

[4] For example a survey among utilities at the end of 2005 and start of 2006 suggested that business required ‘courage’ to make investments where the return is dependent on there being a carbon price in 2013 (Hamilton and Kenber 2006)

Uncertainties considered very important for investment decisions (survey n=20)	Bank	Utility	Oil major	Tech. company
Demand uncertainty				
Output price uncertainty				
Fuel price uncertainty				
CO2 price uncertainty				
Technology uncertainty				
Regulatory uncertainty				
Exchange rate risk				

Table 1 Uncertainties considered by different actors

To implement successful climate policy we need to better understand and address these uncertainties, for example:

- Confidence of technology developers and manufacturers that government policies will be in place to foster demand for renewable technologies and energy efficiency to allow learning by doing and cost reductions to enter the wider market. This will accelerate innovation in low Carbon technologies create confidence that reduction targets can be achieved.
- Credibility of long-term targets will influence governments and oil majors to assess and pursue lower Carbon investment options.
- Credibility of mid and long-term targets increases credibility of mechanisms and instruments like ETS and ensures that they influence investment decisions.
- In the absence of meaningful historic price trends for CO_2 that could allow banks to assess risk of low CO_2 prices, other mechanisms that allows for the use of (cheap) debt/bonds to finance low Carbon projects can be provided.[5]

3 Quantification of the impact of CO2 policy uncertainty

The tricky part of economics is that one can always identify many incentives that influence investment, operation and consumption choices. So how big is the effect of CO_2 policy and price uncertainty relative to other uncertainties, and does it matter for timing or technology choice of investment decisions?

Table 2 illustrates how investors across different sectors emphasis the importance of different appraisal methods for their investment decisions.

[5] For example a price floor reduces the risks for governments of issuing CO2 certificates below a lower bound of estimated social costs of emitting CO_2 and can thus reduce costs for society in addition to facilitating financing. Long-term option contracts on CO_2 prices, issued by governments or private sector, could also provide contractual guarantees that facilitate investment choices.

Appraisal methods important for investment decisions (survey n=20)	Bank	Utility	Oil major	Tech. company
Scenario analysis				
Computational model				
CAP-M				
Value at risk				
Real option				
Calculation of feasible financial structure				
System dynamics				

Table 2 Results of survey among investors as to what appraisal methods they apply

3.1 Does CO2 policy uncertainty matter for the timing of investment decisions?

We will use a very simplified model to illustrate the impact of different modelling frameworks on investment decisions.

Assume an investor has to decide on investing into a power station at costs of c=900 Euro. The future profits are conditional on the stringency of the future climate policy. With p=0.5 probability future climate policy is stringent, and the investor makes discounted net profits of $\pi_{2,1}$=1500 Euro and with 1-p probability the policy is not stringent and the investor will make discounted net profits of $\pi_{2,2}$=500 Euro.

In this very simplified economic model, the investor calculates the net present value of the investment decision is positive, and the investor pursues the project:

$$E(\pi_2-c)= p^* \pi_{2,1} + (1-p) * \pi_{2,2} -c=100$$

3.1.1 Real option approach

The investors could also wait with a decision until there is more information available - including the level of stringency of the climate policy. In this case the investor would only implement the project if a stringent climate policy results in the high profit levels for his project $\pi_{2,1}$ and otherwise not pursue any investment. This increase the expected value of the project

$$E(\max(\pi_2-c,0))=p^*(\pi_{2,1}-c) + (1-p) * 0 = 300$$

Blyth and Yang apply a similar monopoly model to investment decisions in a continuous time model (Figure 4).

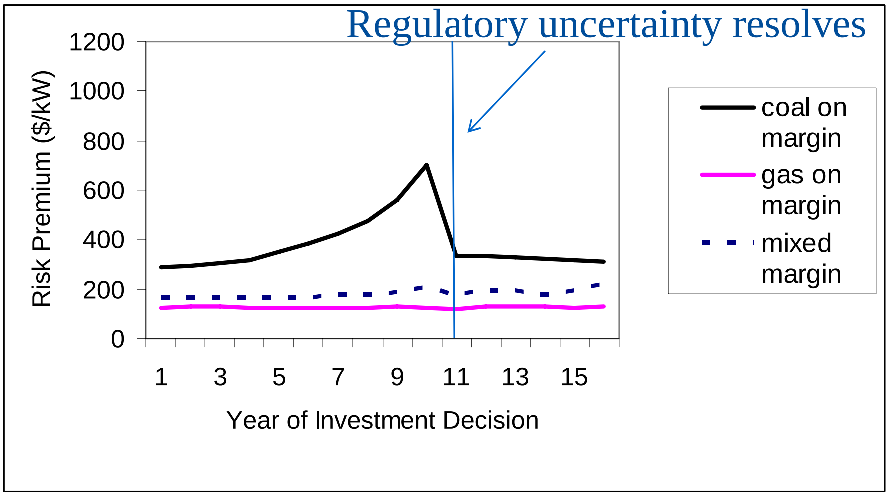

Figure 4 Increased margin required for monopolist to invest in gas power station before regulatory uncertainty is resolved to compensate for option value of waiting (Blyth and Yang, 2007)

This very simple result only holds with monopoly power. In a competitive environment a competitor might pre-empt the incumbent and build the project in period one at expected profits of 100. This might satisfy market demand, and prevent the monopolist of building in period two. This illustrates that the real option of value is influenced by the level of market power in the system.

An additional simplification of the model relates to the investment time frames. Planning, permitting and constructing process of large investment projects lasts many years. While it might be possible to pursue multiple options throughout the initial stages of such a process, eventually companies have to commit to one project and time frame. The time lag between final commitment to a power plant and commissioning varies across technologies but can last several years. Particularly where regulatory uncertainty is a re-curing event – e.g. five year commitment periods – this could significantly reduce the value of waiting for investors.

3.1.2 Risk premium - principle

Various approaches are used to assess the risk premium investors have to pay to access capital if the returns are uncertain. The risk premium results in increased discounting of future returns. A project with stable and secure cost and revenue streams could for example be financed at weighted costs of capital in the order of 6%. Projects with more risky returns create risks for investors and have to offer higher returns. Assume a risky project has weighted costs of capital of 8.7%. (see section 3.1.4]) If funds have to be acquired for example for seven years, then the risk premium increases the costs of the project by the factor $(1.087/1.06)^7=1.2$. This implies the effective costs of the capital investment are 20% higher because of the higher risk. In our example this would imply perceived investment costs increase from 900 Euro to 1080 Euro and thus above the investment threshold in period one. The investment would be delayed and only pursued if there is evidence of the stringent climate regime in period two.

Many approaches are used to explain the origin of such risk premia, the Capital Asset Pricing Model and leveraging capital will be discussed below.

3.1.3 Risk premium – CAPM

The Capital Asset Pricing Model assumes that capital can be freely allocated between various sectors. This allows investors to diversify their portfolios. Any one investor only faces a very limited exposure to an individual project, and is thus not exposed to idiosyncratic project risks.

In this framework, risks only matter for the investor, if they are correlated across the investments in the portfolio. As the investor can diversify across the entire market, only risks that are correlated with the overall market performance influence the risk premium according to the CAP model. The β-factor is generally used to describe the correlation between the returns in the market and the returns of a project/company. According to this model the risk premium depends on the extent to which the profitability of the project is correlated with the overall market performance. This relationship is difficult to anticipate – as the following three examples illustrate.

Assume governments implement a stringent climate policy in the presence of robust economic performance. As the stringent climate policy results in high returns for the low Carbon project, the returns of the low Carbon project are positively correlated with the market performance. The β factor is close to one, and investors require high rates of returns. They have to wait with the implementation until scarcity prices in the market increase and provide the necessary revenue to cover the higher capital costs. This would imply, in our above example, a delay of the project.

It is however unclear how market performance is correlated with climate policy. An environmental disaster might dampen the economic performance and also provide strong evidence of climate change thus driving stringent climate policy. In this case the low Carbon projects returns are high at times of bad economic performance, the β factor is negative, and capital is cheap for low Carbon investment.

Finally, an ‘exogenous’ factor, like the natural gas price, could also play an important role. A strong economy results in higher gas demand and pushes up gas prices. With high gas prices, CO_2 prices increase to prevent that power generation shifts from coal to gas plants as this would increase emissions beyond the emission cap. Both the higher CO_2 prices and the higher natural gas prices would increase the profitability of a low Carbon power station. In this case the performance of the market is again positively correlated with the profitability of low Carbon power investment, and investors require positive risk premia, delaying their investment.

So far we have little historic data on CO_2 prices that would allow for econometric analysis to identify the most important channel. The fundamental analysis of the causalities in turn is very much conditional on the underlying assumptions about fuel prices, generation mix and political economy. This complicates the use of CAP-M to calculate the risk premium, as illustrated more thoroughly in the analysis by Smeers (forthcoming IFRI paper).

3.1.4 Risk premium – Leveraging of capital

An alternative approach at assessing the risk premium starts from the simplified assumption that investors can access two types of finance. Bonds allow for access to capital at low interest rates - if borrowers can credibly reassure lenders that the debt will be serviced. Equity investors are prepared to bear more risk, but require higher rates of return.
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In the previous example debt can be raised for the amount of return that is secure (500 Euro). The remaining 400 Euros of investment costs have to be covered with equity. Assuming debt requires an interest rate of 6% and the equity investors require a rate of return of 12%, then the weighted costs of capital r equal:

$$900 * r = 500 * 6\% + 400 * 12\% \rightarrow r=8.7\%$$

The higher the uncertainty of the future revenue streams of a project, the lower will be the level of debt in the financial structure. As a result the higher the amount of equity required to fund the project. This increases the weighted costs of capital for the project. For an application to nuclear power see White (2006), the presentation by Neuhoff (2007) provides applications in CDM, renewables and gas powered generation.

The approach ignores in the first simplification the correlation of equity returns with the overall market performance. This might be justified by arguing that only a limited group of people has sufficient information about a specific sector to invest in equity within that sector, e.g. the total risk appetite is limited

3.1.5 Systems dynamics – investment cycles

System dynamics models offer the opportunity to integrate many more factors into the investment decisions of market participants. To allow for this additional scope, models make the simplifying assumption that might also capture some aspects of reality that agents decide based on the current situation rather than developing a perfectly consistent vision of the future. Agents might decide based on the current policy framework rather than based on expectations about the future stringency of climate policy.

System dynamics models and agent based models frequently assume that agents' behaviour is not coordinated. If several firms decide in parallel, this can induce investment cycles. Climate policy could induce multiple companies to make their investment decisions in response to key dates/decisions on climate policy. For example earlier versions of the German national allocation plan gave long-term guarantees of free allowance allocation to power stations commissioned by 2012 and thus induced a rush by all companies to pursue such projects. Thus key dates at which climate policy uncertainty is reduced could contribute to cyclical investment behaviour.

3.2 Does CO_2 policy uncertainty matter for the choice of technologies?

3.2.1 Real option approach

Where the option of waiting for climate policy decisions delays investments in one technology type, it can bias investment to alternative technology options. For example, concerns about future allocation methodologies for free allowances affects fossil fuel plants, and could thus delay their construction. In contrast, concerns about potentially low CO_2 price levels are particularly relevant for low Carbon investment and could thus delay their investment. It is difficult to anticipate which effect dominates.

The grey areas in Figure 5 illustrate for which combinations of CO_2 prices and coal/gas price ratio the uncertainty about climate policy could delay investments in any of the depicted technologies.

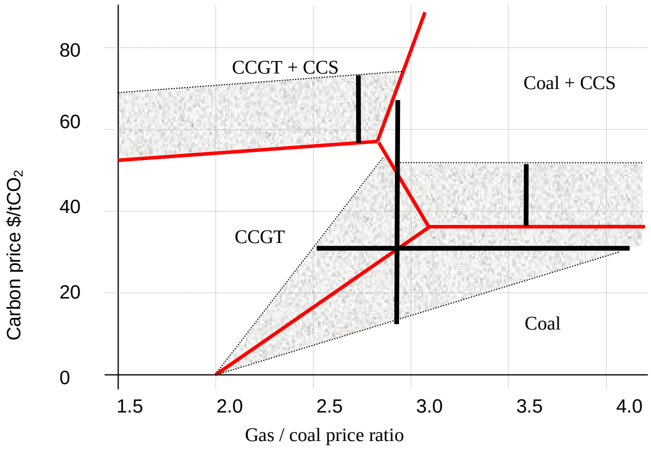

Figure 5 Investment delayed by monopolist if there is uncertainty about a potential jump of Carbon prices after 10 (grey areas) for coal and gas plants with and without carbon capture and storage (CCS) (Yang and Blyth 2007).

3.2.2 Risk premium

Capital intensive technologies are particularly affected by higher risk premia. The following graph depicts the fixed and variable costs of power generation in coal, gas and wind at weighted costs of capital of 5% and 10%. This illustrates the shift towards fossil fuel generation as weighted costs of capital increase.

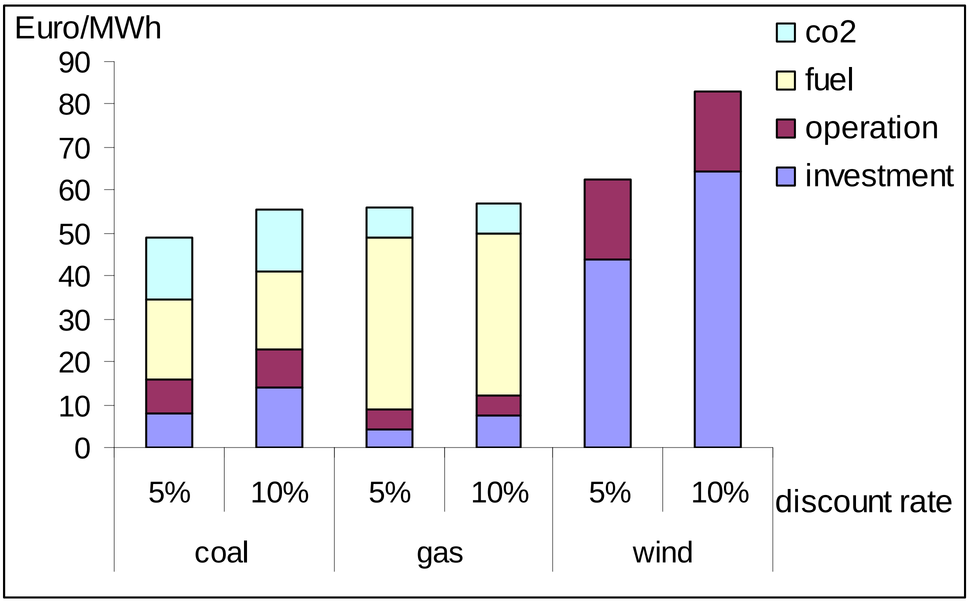

Figure 6 Levelised generation costs of different generation technologies in Germany (IEA 2005)6

3.2.3 Systems dynamics – investment cycles

Investment cycles can have different implications for different technologies.

First, technologies where the time delay between investment decision and commissioning is shorter can pre-empt other technologies. As models with investment cycles suggest that much of the net-profit is made during years with scarce generation capacity, technologies that can be installed faster can better capture and benefit from the scarcity prices.

Second, to satisfy the demand of investors, technology producers have to rapidly produce large volumes of the technology. This favours existing generation technologies where manufacturing capacity is already available and established designs and processes allow for rapid scaling up where required. Newly emerging technologies are disadvantaged, as they have to put more emphasis on learning how to improve performance and reduce costs of the technology. This requires feedback from the product to design and manufacturing process. With rapid scaling up the focus of technology companies can be distracted from learning and the value of feedback from product to production and design might be reduced where the same production approach is replicated across multiple sites.

3.2.4 Fundamental analysis

Fundamental analysis derives future price levels by modelling the interaction between investment and technology choices on the supply side and factors like GDP growth or substitutes on the demand side. Fundamental analysis has always been an important instrument to assess future market shares of different technologies, price levels and uncertainty associated with both. They are particularly relevant where technological or regulatory changes suggest that the future can not be derived by extrapolation from historic trends.

While in principle a fundamental analysis can aim to depict the global picture, in most applications a specific country/region and sector is represented. In this case various factors like fuel prices and international trade volumes have to be postulated as exogenous factors to the model.

Climate policy is another factor that can be reflected in such fundamental analysis. The global economic models that are referenced in the recent IPCC report (2007) illustrate the high level of aggregation that is required in such models. Investors that aim to make strategic – and even more so tactical decisions – about their response to climate policy based on such fundamental models face various challenges.

First, forecasts from aggregate models of economies offer some, albeit potentially biased, insights into potential future evolutions. The law of large numbers suggests that several errors on detailed variables might cancel each other (see Grubb and Ferrario 2006) thus improving the forecast. The level of uncertainty of model results is thus larger for individual sectors than for the overall economy. Assessing past US energy forecasts, Winebrake and Sakva (2006) argue that “Low errors for total energy consumption are concealing much larger sectoral errors .. [for EIA] 5-year forecasts made between 1982 and 1998 industrial sector was overestimated by an average of

[6] Comparing the data for a pulverised coal power plant, a combined cycle gas turbine and an on-shore wind turbine. This is only illustrative - gas prices are currently lower, capital costs for new investment in coal have significantly increased and the concept of levelised generation costs only make sense when assessed in combination with a demand profile or generation system, particularly when considering intermittent generation technologies like wind.

5.9%, and the transportation sector was underestimated by an average of 4.5%. ..no evidence that forecasts within each sector have improved over the two decades studied here."

Second, climate policy is a political as much as a technological challenge. The stringency of future regional and global regimes is likely to be influenced by the process of international negotiations and bargaining. While results of policy processes are already intrinsically difficult to predict, game theory suggests that the interaction of multiple actors, e.g. countries, can result in multiple outcomes. While these outcomes might influence the speed of technology development and level of regional and global CO_2 prices, they are intrinsically difficult to model and incorporate in fundamental analysis.

Third, while in principle sensitivity analysis of the different input parameters to a fundamental analysis provides some indication about the level of uncertainty for future price levels of technological shares, this might not hold for policy uncertainty. As discussed in the previous paragraph, interaction of various actors or countries on the policy side can result in multiple outcomes, but usually the full set of possible outcomes is not modelled.

While we did not discuss in detail the potential implications for timing or technology choices of investment decisions, one of the big concerns is that the difficulty in providing robust fundamental analysis in the face of uncertainty in climate policy allows management to continue pursuing business as usual strategies.

3.2.5 Scenario analysis

In practice most organisations merge the information from fundamental simulations into a smaller set of perhaps four policy scenarios, usually around four, in order to facilitate an intuitive evaluation of investment options.

CO_2 uncertainty has (i) added multiple dimensions discussed above and (ii) makes it even more difficult to attribute likelihoods/probability weights to the different outcomes.

The process of developing credible scenarios within an organisation facilitates communication and people involved in the process will appreciate the insights into the large uncertainties involved. The final scenarios are likely to sound very consistent. They can only capture a small fraction of the possible policy evolutions. Scenarios differ across organisations – reflecting the need to explore the main sets of uncertainties that effect the specific investment decisions.

For example in the power sector, fuel prices and demand growth are traditionally important uncertainties facing investment decisions. During the transition to a low Carbon economy the following factors become equally important for the profitability of investment decisions: future CO_2 prices, level and methodology of free allowance allocation and the impact of renewable policy and technology evolution on future renewables penetration.

The additional dimensions of uncertainty make it difficult to even attempt to capture the range of uncertainties in four scenarios (see Feretic and Tomsic (2005) for a probabilistic analysis capturing some of the dimensions). Companies have to make strong assumptions that various effects happen in parallel to deal with these uncertainties.

This creates significant discretion for companies to evolve their scenarios and makes it more difficult for organisations to associate probabilities with any scenario. It is likely to reduce the credibility of any such scenario. As a result, investment decisions are influenced to a larger extent by traditional approaches and intuition rather than by fundamental analysis. One concern is that senior managers might have a natural tendency to pursue conventional technologies - their longer experience with these technologies offers them a competitive advantage, individually relative to younger staff and as organisation relative to new companies entering the market.

In competitive markets with quick capital turnover, companies that are good in anticipating consumer taste and technology evolution succeed in capturing large market shares. One can thus argue that the market will ‘select’ companies with the best capabilities, including in their ability to create scenarios that allow them to make effective decisions.

However, capital turn-over in most CO_2 intensive industries is historically low, and frequently incumbents have strong or dominant positions in their regional markets. In addition, they have big balance sheets, hence investment decisions might not be scrutinised by banks providing debt, but only by equity analysis. The selection mechanism of the market is therefore likely to be very slow, and even companies with inferior ability to judge good investment choices might continue to operate and invest for a longer period of time. Outside analysts evaluating share performance could thus play an important role in assessing company performance. However, the ability of analysts to effectively judge company performances is limited, as companies only publish limited amounts of information about their scenarios and might even bias this information. For example, if companies were to admit that they think scenarios where their sector does not receive free CO_2 allowances post 2012 are likely, then this would jeopardize their negotiation position for continued free allowance allocation.

3.2.6 Insights from contract theory

Principle agent models assess the optimal contract structure that principles put in place to incentivise their agents to improve their performance. It is frequently assumed that a principle (in our case investor) can not sign contracts based on the efforts of the agent (in our case manager). Hence the principle offers managers contracts that are related to the success of the project. However, managers tend to have smaller wealth than the aggregate group of investors, therefore bearing the risk of their project/company creates a disutility for mangers. Contract theory suggests that principles and agents share some of the risk and agents retain some incentives to put in effort. With increasing levels of uncertainty the principles (investors) have to bear an increasing share of the risk, and agents (managers) face a smaller incentive to improve their performance.

Incentive contracts of managers linked to the share price performance of their company have two implications: First, reducing the level of uncertainty associated with climate policy allows investors to put managers on more stringent incentive contracts and can therefore improve the performance of the economy. Second, good managers would like to exhibit their achievement and sign high powered incentive contracts. The model would suggest that they are interested in supporting climate policies associated with lower levels of uncertainty.

3.3 Summary of methodologies applied

Approach of assessing uncertainty	Timing of investment decision	Technology choice of investment decision
Real option of waiting	Delay overall investment	Use quick, low capital cost fixes, with diverse Carbon implications
CAPM	Uncertain CO_2 prices increase risk premium required and thus capital costs.	Biases against technologies with high capital and low fuel costs
Leveraging capital	Uncertain CO_2 policies can reduce access to bonds	Biases against technologies with high capital and low fuel costs
System dynamics (cyclical behaviour)	Peaky	Undermines organic growth/learning by doing for new technologies. Preference for technology with short lead times.
Fundamental analysis	Uncertainty reduces credibility of long-term targets and results in overall more uncertainty complicating and delaying investments	Uncertainty reduces credibility of long-term targets and thus incentives to invest in low Carbon technologies
Scenario analysis	Uncertainty reduces credibility of policy scenarios and results in overall more uncertainty complicating and delaying investments	Retaining scenarios with limited climate policy puts low Carbon investments at risk and allows management to continue executing BAU strategies
Implications from contract theory	High level of uncertainty makes evaluation and incentivisation of manager and company performance more difficult, favouring incumbent actors and technologies.	

4 Conclusion

Uncertainty about the evolution of climate policy and Carbon prices is to a large extent related to the regulatory uncertainty about the decisions of government. This poses a trade off for governments:

- By increasing their commitment, and defining intermediary targets (both for intermediary time steps and individual sectors) they reduce the regulatory uncertainty and thus facilitate private sector investment decisions into low Carbon technologies
- This does however restrain future policy flexibility and the ability to respond to new information.

The discussions suggest that in the absence of more specific commitments in addition to a 2020 emission reduction target it might be difficult for the private sector to take forward several of the low Carbon technologies and projects. This suggests that early commitment is required to deliver emission reductions, even where this might reduce some policy flexibility.

Further quantitative work would be required to better understand the 'optimal' level of commitment by governments. This is likely to differ between regions according to e.g. whether they are leading the decarbonisation or what level of trust private sector has in government policy.

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