UNDERSTANDING POWER PLANT INVESTMENT DECISION PROCESSES

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Abstract

In order to understand how companies make investment decisions under conditions of deep uncertainty, we interviewed a number of actors in the Dutch electricity sector. Most of the economic literature that is devoted to this question is prescriptive in nature, describing rational methods to the investment decision process (such as real options and portfolio analyses). While these analysis tools play a role in the investment decision, the actual process is much more complicated. The reason is that the investor never has all the information that he would need to make a rational decision. Our research shows that the investment process is guided by a set of satisficing goals, rather than profit maximization; a multi-stage project management approach is used to cope with the lack of information; and the resources for information processing limit the scope of the analysis. We find several differences between companies in their decision making process and goals. These are a consequence of company characteristics such as the company size, ownership, vertical integration and geographic focus. The chosen electricity generation technology and inter-organizational dynamics also affect the investment process.

1 Introduction

Investment in electricity generation is inherently risky due to the long construction times, long life cycles and capital-intensive nature of power stations. The investment risk is exacerbated by uncertainty regarding future fuel and CO_2 prices and changes in renewable energy policy and in market regulations. However, much investment is needed in the European electricity generation sector in order to meet the policy goals for CO_2-reduction and renewable energy and to replace ageing power stations. Therefore it is surprising how little research has been performed on the way in which power plant investment decisions are made in practice. This knowledge is necessary for estimating the effects of policy changes on, for instance, the future electricity generation mix and CO_2 emissions.

In studies of the expected future effects of policy instruments, or of the development of the energy sector in general, investment is assumed to be rational, based on the net present value of projects, perhaps extended to real options analyses or to portfolio assessments. Often full knowledge of the distributions of future costs and benefits is assumed. In practice, this knowledge is not available or incomplete and the investment decision process is much more complex. In this paper, we present the results of an empirical investigation of power plant investment decision making processes. In order to understand how companies make investment decisions under conditions of deep uncertainty, we interviewed a number of actors in the Dutch electricity sector.

The research was partly prompted by the current investment wave in the Netherlands. Over the past few years, about 10000 MW of new coal and gas plants have been commissioned. This corresponds to about half of peak demand and is by all estimates considerably more than what is needed. About a third of this volume consists of powder coal plants, which are the cheapest source of electricity generation at current coal and CO_2 prices but which do not fit with the longer-term climate goals.

Little literature was found on the empirical evidence of the investment process in the electricity sector. Most of the literature for the electricity sector is prescriptive in its nature, describing investment evaluation tools (e.g. Chevalier-Roignant et al. 2011; Wogrin, Centeno, and Barquin 2011). Those studies that were descriptive, such as studies of valuation tools and the capital structure of companies (Graham and Harvey 2001), or the practical application of project management technics (White and Fortune 2002), were not specific to the electricity sector. By contrast, very little research actually describes how companies deal with the deep uncertainty regarding key cost drivers such as fuel prices and future policies.

2 Methodology

If we assume that energy companies are rational, profit-maximizing entities, the problem may be described as one of bounded rationality due to the lack of information (processing capability). Therefore we use the theory of bounded rationality, as was founded by Simon (1955), as the basis for this study. It is true that companies are not fully rational, but we were not able to investigate this aspect in detail (but we will touch upon it). In this perspective, more than only financial constraints apply (such as access to information, information processing capacity and time constraints). As it cannot be determined with any degree of certainty which investment decision and project design is financially optimal, we hypothesize that Simon's (1956) concept of satisficing goals applies. Actors are described as developing coping strategies for dealing with these constraints. In our case, we hypothesise that the main coping strategy is the application of project management practices.

The information presented in this work was gathered using a semi-structured interview approach with power company investment analysts and decision makers. We asked questions concerning the formal objectives and metrics that were used to assess investment prospects, the structuring of the investment process in time (e.g. the application of project management), the actors involved (departments, decision bodies and external consultants), the methods used to evaluate power plant projects and their associated risks, what information was collected and how this was processed.

Given the sensitivity of strategic investment decisions, the interviewees required that they would remain anonymous. Therefore, we cannot present a list of participating companies and interview partners here. However we can provide the following aggregate characteristic of the interviewed group. We conducted nine interviews with one or two employees at a time. The interviewees belonged to eight companies. A majority of the interviewees were stationed in the Netherlands, but some worked in Belgium and Germany. The companies differed in their level of geographic focus. Among the group were companies that had their operations confined to respectively the Netherlands, Europe, or a global geographic scale. The interviewees worked at the following types of companies:

- A bank with a specialised energy desk;
- Six electricity generation companies;

- An energy sector consulting firm with experience with valuation and strategic advice on investment processes at several power companies.

The interviewees' positions in the companies can be summarised as follows:

- Five heads of business development departments;
- One vice president (in portfolio management);
- Two business analysts;
- One former CEO of an energy company subsidiary.

We structured our results in the following way. In the next section, we describe the use of *satisficing* goals that were found during the interviews are presented. Secondly the structure of the investment process in the form of project management, used by the companies to cope with complex information is described, as well as coping strategies within this framework, which are used to simplify and frame information. Finally differences in behaviour as a result of company characteristics are discussed.

3 Investment goals

Most of the company goals found during the interviews displayed a *satisficing* character, as expected by decision theory. This means that instead of optimizing their behaviour over all possible investment combinations, companies make a positive investment decision if a certain set of goals are expected to be met. The most often mentioned goal by the participating companies was "to have a sufficient level of trust in the business case". However, further prompting revealed that this can be seen as a subjective combination of other goals, which may differ per project and even between persons. In all cases, the business case consisted of a financial forecast and risk assessment. Generally, experts speak of a 'good' business case when they have a high level of trust in gaining good financial results throughout the investment life cycle.

3.1 Meeting a financial hurdle rate

Many of the interviewed companies apply a financial hurdle rate. This is either used as a discount rate in some form of a discounted cash flow model (e.g. NPV or NPV margin) or directly compared to the project's internal rate of return (IRR). It thus constitutes the minimum financial performance that the company expects for its projects. The hurdle rate is based on the weighted average cost of capital, adjusted for project and technology risk. The weighted average cost of capital is set periodically by the finance department and is highly sensitive: none the companies would divulge it during the interviews. Companies with a diverse types of projects may apply different rates, e.g. for regulated and unregulated projects. The risk adjustment factor is constructed by risk assessments of, among others, the country, the technology and the specific design of the project.

3.2 Acceptable risk levels

All interviewed companies stated that risk assessments play a critical role, in several ways. Risks are usually stated as the probability of an event multiplied by the monetized impact of the event. If the expected impacts of certain risks in the project are considered too high, the project will not be

undertaken. If they are acceptable, the risks (and their expected monetized costs) will be included in the financial evaluation of the project, which should show that the risks are balanced by the expected returns in order to be considered favourable. In addition, the interviewed companies add the risk assessment as a separate item in the investment information package that is used by the final investment decision makers.

3.3 Healthy cash position

A company's cash position determines its level of freedom to undertake projects to a large degree. The cash position is a critical consideration for all companies, but especially for the companies that are not state owned or have moderately sized balance sheet. A company's cash position also influences its credit rating, and thus affects the financing and procurement conditions that the company can negotiate. In some cases other financing options can such as debt or equity lending can increase the budget, but the associated conditions (e.g. higher capital costs) will be less favourable compared to the own balance sheet.

3.4 Strategic goals

All interviewed companies stated that the degree to which a project adds to a company's strategic goals is a criterion in every part of the investment process. This is part of the prescribed documentation in the gate reviews of the investment process. This criterion is more than a combination of the other investment criteria. The executive board needs to be able to explain the rationale behind investments to different kinds of stakeholders (e.g. share-holders, environmental groups and employees). It is also a check to ensure that company-wide goals are not superseded by alternative goals.

3.5 Relative performance to the sector

Several interview partners stated that the relative performance of the company with regard to competitors can be an important goal during the investment process, since it influences the shareholder value. Depending on the risk averseness of the executives this could lead to "herding behaviour" in the market, to hedge the company's performance against the performance of competitors.

4 Organization of the investment decision making process

The main coping strategy that energy companies apply is that they structure their investment decision process according to the rules of project management(PMI 2008; Meredith and Mantel 2006; Bosch-Rekveldt 2011). While all companies that invest in power plants appear to be using this approach, they vary in how they apply it. The project management methods applied by energy companies are used to organize the processing of incoming complex information. These mainly include the project decomposition in time (or stages), as well as in dividing the necessary task of processing information among departments within and outside of the company.

4.1 Project management over time

A central information processing and decision strategy from project management that all companies apply when investing in a new power plant is the decomposition in stages over time. This enables companies to control the project development costs, which according to one interview partner, are in the range of 2-5% of the total investment costs.

The stages within the participating companies have different names and sometimes the main stages are split up into sub-stages; however, the following pattern is followed by the companies:

Before the specific investment process takes place, a companywide investment strategy is set (that incorporates portfolio considerations to varying degrees and relies on the already introduced strategic goals) and which usually includes a scenario analysis (cf. later part about treatment of uncertainty). This is a basis for the following stages:

- During the "scanning" or "business development" phase initial market opportunities are explored, which fit with the investment strategy. A business case with large confidence intervals is prepared, which also includes the location of the power plant.
- During the "scouting" or "scoping" phase a specific market opportunity is specified, and more detailed business cases are prepared including uncertainty and risk considerations.
- During the "design", "definition" or "front-end development" phase(s) the power plant project is detailed to such a degree that it can be financed and constructed. This also includes tenders for the entire power plant (turn-key project) or parts of it, as well as the permitting processes.
- A final investment decision is made.

Each stage is closed by a gate review, where the project is compared against the satisficing goals of the company (strategic fit, hurdle rate, risk and uncertainty assessments). The gate reviews are all performed by investment committees with a diverse group of members to minimize issues such as group think, bias and lack of knowledge, and in order to keep up the tension on underlying investment assumptions.

In general simplifications are decreased throughout the investment process. More detail is added along the way, concerning the business case (more detailed and sophisticated modelling techniques, including risk assessments), but also other assumptions regarding the technical design and regulatory conditions. The bandwidth of expected financial outcomes is expected to decrease considerably over time by all companies, as more and more details are specified with a greater degree of detail and certainty. Due to the length of the investment process (which differs between technologies) information and assumptions are regularly updated in intervals.

It is attempted to make choices that reduce much degrees of freedom (e.g. location choice, technology choice) early in the process. This simplifies design and avoids unnecessary activities that consuming large "Devex" budgets. Expensive activities are performed preferably in the final stages of the investment process (e.g. detailed design and permit applications).

4.2 Organizational aspects of project management

Information processing is divided between several departments: all companies have strategy, business development, technical development, production and trading departments.

Every department receives specialized tasks and frequently should also handle the accompanying risks. An example is 'tolling' within one company, where the production handles technical risks and trading handles market risks. In many cases the business development department is responsible for the integrating the investment process.
Similar to other corporate environments, the information processing and decision making is distributed in different hierarchical positions (both for banks as well as power companies). Key groups are portfolio managers, analysts, business development heads, investment comities and executive board members (at power companies). Several issues are relevant with regard to hierarchies;
Projects with high capital expenditures (Capex) tend to travel 'top-down', while some smaller projects can originate 'bottom-up'. This is especially true for larger international companies, where the number of hierarchical levels is larger. The attention of higher hierarchical layers tends to intensify in later stages of the investment process and with higher Capex projects.
Outsourcing to engineering firms, law firms and strategic consultants happens at all companies. The level of outsourcing will intensify at later stages due to the considerable costs involved and the level of detailed knowledge required. Acquiring all documentation for formal procedures such as permit approval and external financing consumes a large part of the Devex budget. However the outcomes of these formal procedures (e.g. the building permit) in these phases add much financial value to the projects.

4.3 Intra-organizational dynamics

In this research intra-organizational dynamics turned out to play a role in the investment processes. Their workings can be a study of considerable size in other scientific disciplines. However, since these were not the main focus of our study, only a limited number of intra-organizational dynamics that were stated by the experts are given here:

- The final decision makers (executive boards) are accountable to owners, such as shareholders or a limited number of municipalities. The executives will take the anticipated results of owners of their actions into account in managerial decisions. One effect can be 'herding' in the sector since the position of executives is compromised when the company behaves much worse than the sector as a whole.
- Analysts will often take the anticipated results of executive decision makers into account when making investment process choices.
- Mergers and acquisitions between power companies have occurred in the last decade: its culture, access to information, ability to process information and decision rules can change when a company is acquired or merged. Naturally it will also change formal company characteristics (e.g. size or geographic focus).
- Power play in company politics was a frequently described dynamic by experts. It was stated to happen by owners to executives and also down the formal company hierarchy.
- Social behaviour within the company can occur and this can lead to motivated (or 'goal') reasoning, where the success of the project proposal becomes a goal itself for the employees involved. The large amount of work performed, social desirable behaviour, the desire to "outperform" competing departments, real life experience in implementation,

having a job continuity or enjoying prestige linked to large projects were stated as possible reasons.

- The analysts desire for the investment process to "instil trust" can influence the actual investment process, e.g. through changes in data representation or smart timing. This is stated to happen frequently during investment processes.
- Spending the budgets was stated to be an observed behaviour within some companies. One rational stated by the experts is that employees are used to consume the budgets to avoid future cutbacks. A connection to a history of state or municipal ownership is stated in particular by experts.
- The use of different financial decision rules (e.g. NPV, IRR) was stated to come from intra-organizational events in the past. Personal preferences and experience in use methodologies by employees can influence this coping strategy.
- External political influence can also play a role, especially at companies with governmental shareholders.

The effects of intra-organizational dynamics on the investment process can be diverging. This investor differentiator can lead to a multitude of decision making constraints in a multitude of ways. Currently, information is lacking in the form of a proper organization of intra-organizational dynamics as well as sufficient insights in specific aspects and their relevance. So an unequivocal explanation cannot be supplied in this review. However one trend is stated to indicate polarity. A large degree of any of these dynamics increase the chance that the decision process shifts away from analytical type decision making towards decision making with political aspects.

5 Information processing

When power companies invest in a new power plant, they need to consider and interpret an overabundance of possibly inconsistent information and project them into future developments that affect the profitability of their power plant investment project. The categories of information considered include, amongst others, fuel price developments, competitors' behaviour, regulatory development and technological development. In a second step, the gained knowledge deduced from this information has to be effectively communicated within the company to aid the decision making process. The companies under investigation have thus developed, or adopted, strategies to deal with this problem:

- They use a nested uncertainty and risk approach, where in a first step uncertainty is treated by a discrete, possibly qualitative scenario analysis, and in a second step that builds up on the first, the better known risk are treated by numerical models and as well as distributions based on past observed data.
- They use investment guides to standardize information according to well-known metrics and representations.

These points will be discussed in more detail in the following.

5.1 Treatment of uncertainty

To deal with uncertainty, the companies indicated that their methodology frequently resemble aspects of the scenario methodology developed by Royal Dutch Shell. This selects a number of

uncertainty axes (Schnaars 1987), on which a scenario analysis is based. Frequently stated uncertainty axes are:

- Uncertainty in macro-economic development
- Uncertainty in public policy (environmental and market regulation)
- Uncertainty in consumers' environmental sustainability focus (e.g. coal to gas ratios)
- Uncertainty in technological development
- Uncertainty in sector structure (capacity markets, interconnection)

The first step in the treatment of the individual axis is to see whether the current lack of knowledge is due to true uncertainty (in the sense of Knightian uncertainty (Knight 1921)), or if the bandwidth of uncertainty can be reduced since it is due to knowledge uncertainty. This is aided by sessions with people from various departments, in order to draw in a wide range of expertise, as well as create a diverse set of opinions, and challenge common assumptions. If no in-house knowledge is available specialist external services (e.g. lawyers, engineers, political specialist) are contracted.
Finally the company comes to a set of plausible, congruent future pathways. These are often a starting point for modelling assumptions in the risk treatment during the investment processes.
Finally, not all companies use the same uncertainty categories, and any uncertainty that is not considered in this step of the process is frequently ignored from that point on of the investment process.

5.2 Treatment of risk

On the basis of the scenario analysis, the better quantifiable risks are assessed in accordance to the investment guide (also see next section). Companies focus primarily on well-known risks with perceived high impacts. Risks that are given much attention are:

- Building permit risks (key risk for all);
- power price volatility (key risk for all);
- land lease risks (key risk for all);
- subsidy risks (key risk for renewables);
- natural resource availability risk (such as wind speed yield risk: key risk for renewables);
- technical risks in the power plant;
- grid connection risks ;
- construction risks ;
- fuel price risk;
- carbon exposure risk;
- risks in partnering.

The outcomes of the risk assessment are frequently simplified to the potential impact distributions and either based on past experience saved in historical data sets, or are derived by simulations and models which take other underlying distributions into account (Monte-Carlo simulations). The assumptions regarding the risk assessment can differ between the different scenarios of the uncertainty analysis.
Naturally the power price and merit order risks receive special attention. All companies use elaborate forecast models based on long term future merit orders expectations, fuel price assumptions and demand assumptions that come from the scenario analysis. The models give estimates for power prices in different timeframes, for up to 40 years. The merit orders are based

on assumptions regarding changes such as: decommissioning of plants, interconnection changes and new investments. These are elaborate and confidential models. The outcomes are revised periodically or when major changes occur. A second important source of electricity price projections in the medium term are electricity price futures, which are used to hedge some of the price risk once the final investment decision is made.
Systemic risks are frequently simplified to the 'Beta' in CAPM´s. The weighted cost of capital is usually supplied by the financial department. This data is sensitive to competition and is revised periodically. It is not entirely clear whether this at times leads to a double-counting of risks, with regard to the risk assessment.

5.3 Standardization of information

The central tools to standardize information and to come to an effective communication within the companies are the investment guides. These define the standard metrics, representation of data and the reports that are used to inform other departments, as well as the stage gate committees.
By using metrics such as the IRR, the NPV, the RAROC, as well as diverse risk measures, such as P50 or P90 values, or standard graphs such as risk tornado plots, information is simplified to well-known measures that are interpretable by a wide range of employees. While this step is necessary to communicate information, frequently potentially important details are lost, and it serves as a hindrance to the usage of more complicated metrics or models, which are not as easily communicable (for example real options analysis).

6 Differences between companies and technologies

Several company characteristics, as well as the chosen conversion technologies, were found to cause differences in company goals, information processing and the treatment of risks and uncertainties.

6.1 Company size

Company size was frequently stated as a reason for different choices in investment processes between companies. When the experts spoke of company size their focus was primarily based on the financial value of the power company's asset base.
The interviewed experts stated that company size influences the investment processes in several ways: in changing the importance of at least one goal, information processing and dealing with uncertainty. One example is the importance of maintaining a healthy cash position. While this goal is shared amongst all companies, the relative effect of the Capex requirements for a new plant on the cash position will be smaller when the balance sheet of the company is much larger. Secondly portfolio considerations when making investment decision will play a larger role for companies with a larger asset base.
The company size also affects the information processing in various ways. Larger companies will usually have:

- More specialized departments to gather and process information. This allows them to perform more elaborate analyses (such as power price forecasting, strategic scenario

analysis and Monte Carlo type simulations). Smaller companies will sometimes opt to outsource this kind of analysis or simplify their models,

- Less need for external capital supply such as debt or equity financing compared to smaller companies (for the reason stated above).
- More preceding portfolio analysis and the following portfolio choices set by a central investment strategy is done at corporate headquarters. At smaller companies the number of management layers will usually be smaller and the information processing capacity more limited. Therefore, business development managers within smaller companies will usually have more influence in the portfolio consideration.
- More data and insights derived from previous projects on technologies, but also from greater market experience. This is due to the larger power plant portfolio of bigger companies. Smaller companies will often have to buy this information (if it is available) or focus more on specific technologies. Additionally the incentive to invest in technologies to gather experiences is lessened.
- A larger degree of formalization of their investment process in the investment guides (to enable comparison between a multitude of problems and because the executives will need to spread attention across more projects).

Finally, company size also influences the way the companies deal with uncertainty. Larger companies will usually have:

- The possibility to develop their own strategic scenarios that indicate possible futures. Such projects can be too elaborate for smaller power companies. In this case (parts of) the scenario analysis are procured from external sources.
- More means to influence policy uncertainty. “Lobbying” will be easier for large companies compared to smaller companies (they have more influence on local economic conditions and can afford to attract lobbyists).
- The possibility to use more flexible analysis methods such as real options analysis, which are more frequently used in larger companies. One reason is the costs and specialist knowledge involved, which can be spread over several projects.
- The possibility to diversify more between countries, the supply chain and the generation portfolio (for large vertically integrated multinational companies).

6.2 Ownership

Company ownership is based on the distribution of equity. It influences the investment processes in several ways: in changing emphasis of goals and in a limited way in dealing with uncertainty. Several goals are influenced by a company’s ownership:

While all companies have the goal to not underperform the sector, electricity companies that are traded on the stock exchanges will have more pressure to show good performances in comparison to companies with owners such as municipalities and federal governments. Municipalities and federal governments can afford more focus on long term goals (such as environmentally sustainable production) compared to private shareholders.

Within the companies reviewed, companies with a large ratio of municipality or state ownership did not tolerate the use of hard coal, lignite and in some cases nuclear. Sustainability as a strategic goal can thus be a very influential factor in the investment behaviour. Additionally companies

owned by the state or municipalities also considered the effects on local employment, which provides a considerable driver in the location choice of power plant building sites.
Naturally the company ownership also affects the access and availability of equity capital:

- State owned companies will have different access to capital compared to publicly traded companies. In certain cases it was stated that the state would withhold a large ratio of the profits as dividends; however, for new power plant investment options the state would also provide additional funding if necessary.
- Sometimes state or municipality owned companies can afford a less risk adverse profile due to the relatively high financial robustness of their owners. Certain companies actively use this strategy of risk seeking as a competitive advantage compared to publicly traded companies. Similar considerations apply for dealing with uncertainty.

6.3 Vertical integration

Vertical integration is seen as the level to which a company holds several positions in the supply chain. Experts stated that vertical integration influences the investment processes in several ways.
The level of vertical integration influences the investment process, since the added value of an investment over the entire portfolio should be taken into account, and will be rising with further integration throughout the supply chain (such as combined positions in natural gas, generators and trading). More interaction effects between different company parts need to be considered in such a case.
The level of vertical integration also influences information processing: a company with a high level of vertical integration will have more access to information compared to a company without vertical integration. Positions throughout the supply chain can supply vital information such as more accurate fuel price expectations from feedstock positions or better access to market information via traders.
Vertical integration can also give companies options in dealing with uncertainty. The different positions in the supply chain give it more flexibility in hedging its risks, since it can often be its own counterparty. This flexibility can be used to outperform competitors.

6.4 Geographic focus

Within the investigated firms the geographic focus varied between a national, a European and a global focus of the power company. The geographic focus was found to influence information processing, the management of risk and the dealing with uncertainty in the investment process.
For companies with a broader geographic focus (e.g. not being confined to one country) it becomes important to include more sources of information, and its representation in the investment process. Separate risks such as country risk and currency risk will have to be taken into account, to compare power plant investment options in several countries.
The geographic focus also changes the options of dealing with risks in the investment process. Companies with a broader geographic focus can diversify their business more, which opens up further risk management options (e.g. diversifying of generation capacity across nations to minimize aggregated country risks). This can lead to changes in information access and uncertainty

in the power sector (e.g. a global company can even choose to spread its risk exposure over several continents).
The geographic focus was also mentioned to give the option of "shopping" for favourable subsidy characteristics between countries in time. This is not possible for power companies with a national focus.

6.5 Technology specific risks and uncertainties

Besides differences in investment processes driven by company characteristics, another driver of difference in the investment process is the chosen technology. In this research, the most obvious distinction stated by experts was between renewable and conventional power plants. Their differences in technology specific risk and uncertainties lead to several changes in decision making constraints and resulting coping strategies stated by the experts:

- Uncertainty in the sector regarding technological risks and regulation are larger for renewable power plants. This, and relatively higher capital intensiveness lead to capital structures with more equity or debt lending for renewables compared to conventional plants. In this way the electricity company changes its risk exposure (risks are distributed among and between the investors). It also attracts more information processing capacity and information access from external financial partners which supply part of the capital.
- When there is a low electricity market exposure of renewables, set by the regulatory framework, the investment process has a lower focus on electricity and fuel price risks, but instead includes more issues such as volume risk introduced by monthly, or even yearly production variations, permit approval risk (e.g. wind needs relatively large spaces) or uncertainties in the subsidy allocation process (e.g. tendering mechanisms). Depending of the in-house knowledge this also leads to a larger degree of outsourcing and reliance on external experts.

7 Conclusions

The literature suggests a number of rational methods for appraising investments in power stations such as NPV, real options and portfolio analysis. However, in practice, not all the necessary information is available for making rational decisions. Generation companies cope with this lack of information, and with their limited resources for information processing, by applying a multi-stage project management process during which they gradually reduce the scope of the options that they consider and refine the information that they collect and process. This can be considered their main, structuring coping strategy, in the terms of decision theory.
A second aspect is that the formal goal of maximizing economic returns is replaced by a set of goals, which need to be 'satisficed'. The 'Meeting a sufficient level of trust in the business case' was a key criterion. The application of this criterion turned out to be subjective and different per company, but all interviewed companies had in common that they applied a financial hurdle rate. The second key criterion was financial continuity, which was operationalized as the manageability of risks and the maintenance of a healthy cash position. Conformity to the company's strategic goals also played a role.

The lack of information regarding future costs and benefits leads companies to consider a multitude of possible futures. Far more futures can be envisaged than can be analysed using the companies' highly detailed, time-intensive market models. Therefore, companies apply a multi-stage project management process during which they gradually reduce the scope of the options that they consider and refine the information that they collect and process. The way in which information is collected, divided between departments and processed in stages also plays an important role, as well as how the information is communicated to other departments and decision bodies. The different stages of the analysis are performed by diversified investment committees in order to minimize issues such as group think, bias and lack of knowledge. The companies simplify exogenous uncertainty by choosing a limited number of scenario variables (or "axes") of uncertainty as a basis for evaluating possible futures and their outcomes. Frequently stated 'uncertainty axes' are macro-economic development, public policy, the value which consumers place in sustainability, technology development and sector structure. Clearly, the choice of scenario variables can have a significant impact on the outcome of the project evaluation.

The decision process itself is influenced by several factors. Intra-organizational dynamics between the board and shareholders, but also between analysts and the board play a role. Power play in company politics was frequently mentioned in the interviews. Social behaviour such as 'goal' reasoning and personal motives were also found influence the investment process, for instance because having been involved with a large project yields personal benefits, regardless of the success of the project. Formal company characteristics (such as size, vertical integration and ownership) also have an important impact. Vertical integration and ownership affect companies' interests, while their size affects their information processing capabilities. Smaller power companies were more apt to rely on consultants, whereas larger companies relied more on in-house knowledge. Finally, investments in different types of technologies were not treated the same. The main distinction is between investment in conventional and in thermal capacity. For renewable energy, policy and development risks were the key issues, while electricity price and volume risk played less or no role, given that the regulatory framework shields them from the market.

However, there are also several limitations to our research. While the interviewees were guaranteed anonymity they might not have been willing (or able) to completely disclose all relevant information about their own company, such as their hurdle rate as well as strategic considerations with regard to their competitors. Secondly, due to the limited time during the interviews, and its broad scope, not every topic could be discussed to a very detailed level. Especially detailed descriptions of the project management process, the usage of financial valuation tools and electricity market models, as well as how strategic portfolio choices are made would need separate dedicated interviews with experts (given that they are willing to disclose such information). Finally, only a limited number of experts within a limited number of companies were interviewed. The results should thus been seen as a first exploration of the investment process under real world constraints.

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