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VALUATION OF POWER PLANT INVESTMENTS IN GERMANY BY USE OF BAYESIAN INFLUENCE DIAGRAMS

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OVERVIEW

Power plant investors face large uncertainties due to ongoing liberalization, climate policy, and long investment horizons. We conduct a probabilistic appraisal of power plant investments within the framework of Bayesian decision theory. We use a Bayesian influence diagram for setting up a discounted cash flow model and analysing the profitability of power plants. As we explicitly model merit order pricing, we can analyse the pass-through of random fuel and carbon costs. We derive probabilistic statements about single investments and company portfolios and explore the sensitivity of profits to variations of select input variables. For the currently prevailing German electricity market, we argue that investors may lack incentives for new investments in fossil generation.

METHODS

Quantitative risk analyses naturally include probabilities. Particularly facing regulative risks, common frequency interpretations of probability are of limited use. In Bayesian theory, probability is a personal measure of uncertainty, expressing degrees of belief on the occurrence of events. Sources of these probabilities may be data, expert interviews, and online markets and questionnaires [1]. Influence diagrams allow decomposing complex risks via use of conditional stochastic independence, and facilitate the analysis with help of graphical representation.

We use a stochastic extension of the DCF model described in [2] to examine profitability of fossil fuelled power plants (hard coal and lignite plants with and without CCS as well as CCGT plants) in Germany. For modelling competition, we pool 113 nuclear and fossil power plants of the four big German electric utilities in a single merit order. Additionally, we assume replacement for all power plants using select replacement strategies. Based on this merit order, we use simple heuristics to determine load factors and electricity prices and thus to compute cash flow statements over the remaining lifetime of existing power plants and the whole life-cycle of replacement plants. Moreover, we analyse the importance of various drivers on the profitability of replacement plants.

RESULTS

We find that variables most important for levelised costs are not necessarily the key drivers of the net present value. For all four major German electric utilities nuclear and lignite-fired power plants are the main factors determining the NPV of their current power plant portfolio. Under the conditions currently prevailing on the German electricity market, however, it often no longer pays to invest in large-scale fossil fuel-powered generating capacity. This applies even without taking emissions trading into account, or in the case of low CO_2 prices. High CO_2 prices, in contrast, can enhance the value of the portfolios of existing power stations. Moreover, companies will probably only diversify their portfolios by investing into gas-fired and CCS-plants when they expect high CO_2 prices. The roll-out of renewables, however, further deteriorates the investment climate for fossil generation.

CONCLUSIONS

For understanding the impacts of varying fuel and CO_2 prices, it is adamant to understand and model merit order pricing and the extent of subsequently passing through fuel and CO_2 costs in a competitive environment. We have complemented this modelling approach with deriving subjective probability statements on future fuel and CO_2 prices discussed in stakeholder dialogues with sector experts and studying the propagation of these probabilities in a Bayesian influence diagram.

In these stakeholder dialogues, we have openly communicated that our quantitative risk analysis of power plant investments only takes into account parts of the uncertainty involved due to complexity and interdependencies hard to model. We have also discussed that the resulting probability distributions are highly conditional. Nevertheless, our experience from communicating with stakeholders confirms that the use of influence diagrams combined with suitable software increases usability and allows more versatile and less error-prone analyses than spreadsheet calculations. Moreover, involving stakeholders into deriving input probabilities makes them partners in the scientific process and gives them ownership of the results. This makes the approach suited for stakeholder-based science and consulting.

REFERENCES

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