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# *ANALYZING INVESTMENT RISKS IN CONVENTIONAL AND RENEWABLE ENERGY DOMINATED ELECTRICITY MARKETS*

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**Overview**

The rise of renewable energies (RE) worldwide and especially in Europe will lead to significant changes in electricity markets. A particular important one is that the "industry is moving from an ´OPEX world´ into a ´CAPEX world`" (CGSP 2014:91). This increase in capital intensity comes with higher investment risks, because the up-front capital costs are sunk and are not correlated with expected revenues during the operation time (IEA 2014). While there is a stream of literature focusing on investment risks of RE under different support schemes (e.g. Klessmann et al. 2013, Fagiani et al. 2013, Kitzing 2014) and the general impact of high RE shares on the market (e.g. Steggals et al. 2011, Winkler & Altmann 2012), there is so far no study that analyzes numerically how investment risks in a RE dominated market differ from the risks in conventional market. To address this gap, we analyze the investment risk of RE and fossil technologies in a pure market setting without additional "de-risking" measures to compute total investment risks. In addition, it is well known that technologies are affected in a different manner by the same risk factor (like fuel costs, carbon prices etc.) and thus each technology has its own risk pattern (e.g. IEA 2003, Gross et al. 2007). Hence we analyze how risk patterns change in RE compared to fossil fuel dominated markets and how the risk for single technologies and the overall portfolio risk changes with higher RE shares.

**Methods**

We extend the approach of Roques et al. (2008) who do Monte Carlo simulations with an optimization model to incorporate important market interactions instead of a simple cash flow model (see also Lynch et al. 2013, Kitzing & Ravn 2013). We model numerically the influence of risk factors on the investment risk of different technologies from an investor´s point of view using an investment and dispatch optimization model with a horizon of 30 years and typical days. In a first step a capacity mix for given deterministic input parameters is calculated (greenfield approach; for German demand and availability factors). In a second step, the former endogenous determined capacities of the first year are an exogenous input in a second model, which is – except the input parameters – identical to the first model. In the second model we assume distributions of important input parameters like demand, plant availability, carbon and fuel prices. By running the second model 1000 times (Monte Carlo simulation), while each run itself is deterministic and includes a random draw from the distribution curves of the input parameters, we get distribution curves of the NPV´s of each technology. This procedure is done twice, once for a conventional and once for a RE dominated market. The former includes today´s investment costs, while in the later RE investment costs are substantially lower, which results in a larger share of RE, while all other inputs stay the same. Up to this point we can analyze how the investment risks differ between technologies within each market and between the two markets on a stand-alone basis. In the last step we take the NPV distributions and their correlations to compute optimal portfolios to evaluate the overall portfolio risk and the efficient shares of each technology in both markets.

**Results**

Preliminary results confirm the findings of Roques et al. (2008) and Lynch et al. (2013) that gas plants are to a certain degree "self-hedged". However, the correlation between gas and electricity price decreases in the RE market, due to the fact that gas plants are less often price setting. Instead volatile RE more often set the price which increases the investment risk for gas plants. Moreover, RE technologies have a high share of fixed costs and negligible variable costs, which leaves them unaffected by cost risks, but exposes them to revenue risks. Due to this so called "operating leverage effect" RE are rather risky plants. Most importantly, compared to a deterministic scenario without risks RE shares are higher in a fossil dominated market because of diversification effects. However, in a RE dominated market RE shares are lower compared to the deterministic framework due to their unfavorable risk pattern. Finally, the portfolio optimization indicates that for a given expected return the risk increases with higher RE shares.

**Conclusions**

Our paper confirms that the costs of risk are an important factor in liberalized electricity markets. Especially scenarios with very high shares of single technologies or technologies with similar risk patterns (e.g. Wind and Solar) seem to compute rather unlikely market results because investors factor risk and diversify. Hence if policy makers foresee high shares of RE in the future, "de-risking" (Schmidt 2014) must very likely be part of respective policies because of the higher overall investment risks in RE dominated markets. While even today some argue that risk could support unfavorable boom & bust investment cycles (Arango & Larsen 2011, Cramton & Ockenfels 2012), our results suggest that this issue will be more important with higher RE shares. Clearly, this has important implications for market design that deserve further research in the future.

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