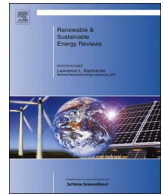




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# The investor-specific price of renewable energy project risk – A choice experiment with incumbent utilities and institutional investors

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## 1. Introduction

The uptake of renewables across Germany has dramatically changed ownership structures on the emerging energy market. Previously, investments in German energy capacity were largely driven by four utility incumbents, dominating conventional generation infrastructure with a market share of 76% in 2012 [7]. Since then, German wind and distributed solar capacity has come under the control of new market entrants. Private and institutional investors in particular have led to a re-structuring of ownership. Their aggregated market share amounted to 88% of renewable energy capacity, making private (46.6%) and institutional investors (41.5%) significant players in the German energy transition [76]<sup>1</sup>. Earlier literature has linked institutional investor's specific interest in renewable energies to the prospects of making a moderate return at reasonable risk levels, a low degree of capital market correlation and the prospect of long-term investment maturity which will generate a steady income for long-term liabilities. In particular, the backing provided through government-induced remuneration schemes makes renewables a perfect match for investors with low risk tolerance (e.g. pension and life insurance obligations). The interest of private and institutional investors is further strengthened by the currently low or negative interest rates on global capital markets [33,54,76].

Surprisingly, most of the recent literature has not accounted for this significant shift in ownership structure. Researchers have primarily been concerned about explaining incumbent utilities' manifold reasons for opposing renewable energies [40,73,77,80].

Literature about other professional investors is scarce, and when it exists, has a strong focus on venture capital or private equity investors and particularly their preferred policy designs [10,46,9]. With the goal of securing investment volumes of 550 billion Euros in order to achieve 80% renewable share in gross energy generation by 2050 [6,8], research on this topic is gaining in importance. A better understanding of the differences in investor-specific risk perception of renewable energies might help inform arguments about future ownership structures and the provision of necessary capacity. In the case that policy-makers do not understand the needs and pre-requisites of investor

engagement, they may either (1) create an unattractive investment environment in which the necessary investment becomes overdue, or (2) over-incentivize renewable energy investments, leading to over-capacity and high financial costs.

The paper is written to bridge the literature gap by describing research that involve 1,659 investment choices by 52 managers from incumbent utilities<sup>2</sup> and institutional investors. The objective of this paper is thus to elaborate differences in the overall willingness to invest between institutional investors and electric utilities on the German renewable energy market. This paper may serve as a starting point for creating made-to-measure policy based on required capacity and market needs.

The remainder of the paper is structured as follows: The following section shortly reviews the relevant literature. Section 3 describes the applied experimental design, including methods, attributes and levels, and the design of the questionnaire. Section 4 describes the results of the survey and choice experiment, including utility estimates, willingness to accept calculations and a market simulation. Section 5 summarises the paper by providing conclusions about the main research targets and limitations.

## 2. Theory

Borrowing from Bentham's [3] utility theory, Markowitz [49] was the first to adapt this concept to portfolio optimisation and the institutional investment context. More precisely, he identified the fact that any rational investor (the assumption of rationality is assumed in classical and neoclassical economic theory) will require returns in proportion to the risk to which they are exposed. Alongside Slovic et al. [71] who recognized early on that the risk and return profile of an investment cannot fully be explained by referring to market risk, an increasing stream of research highlights the subjective and behavioural component of decision-making processes. Among the authors, Simon [70] argued that decision-makers opt to sacrifice rather than pursue optimal solutions. In addition to this proposition, prospect theory, as proposed by Kahneman and Tversky [31], postulated that individuals evaluate potential losses higher than potential gains.

These and other behavioural economic contributions have created the foundation for further research into investor-specific perceptions

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<sup>1</sup> Trend:research and Leuphana Universität Lüneburg [76] conflate institutional investors and strategic investors (excluding utility companies). For reasons of simplicity, this survey only refers to institutional investors, so have adapted details about their market share and investment volume.

<sup>2</sup> The terms "electric utility", "incumbent utility", "utility company", and "utility investor" are used interchangeably within this paper.

about investment risk and return [17,21,35].

Most pre-existing risk-perception research in the energy context focuses on incumbent utilities and their reluctance to participate in the renewable energy age. Widely discussed arguments include the existence of fossil infrastructure that complicates the transformation due to its high financial and human capital investment resulting in path dependency and the slow adaptation of fixed firm structures [4,40,50,73,77], the overestimation of renewable energy project risk [27] and finally, the issue of which new business models may overcome the status quo [26,42,60,61]. Literature about the risk perception of renewable energies has mainly been designed with consumers in mind. It includes research, for example, about preferences for smart metering, service attributes or the supply contracts of utility companies, as well as the influence of eco-labels on consumer choices [18,20,30,34,5,67]. Research that treats consumers as renewable energy investors, has focused on their preferences for renewable energy investments, including their motivation and preferred options for financial incentives, technology, location and professional partners [12,15,66,75].

A few exceptions address the general risk perceptions of professional investors towards renewable energy investments [10,19,50,80]. First, pre-existing research with professional investors has mainly dealt with the interests of venture capitalists or private equity companies [10,25,80,9] in financially participating in clean technology, while a smaller research stream has addressed project developers [45,46]. Here, the authors argued that venture capitalists and private equity investors are early-stage investors so learning about their choices facilitates understanding of future industry booms and movements. In the meantime, renewable energy has become increasingly mainstream and institutional investors are now established market actors [76]. As a result of the experience they have gained and knowledge of their market interests, this paper investigates institutional investors in addition to incumbent utilities or venture capitalists/private equity investors. Second, previous research has investigated parts of the investment decision (e.g. policy and regulatory risks and frameworks for professional investors, diversification risk) in isolation, rather than in a natural decision framework [14,19,45,46,50]. A few research streams have investigated the preferences of investors relating to entire investment projects; however, the scenarios for appraisal involved making abstract, hypothetical assumptions (e.g. technology attributes range from less mature to mature) and were not based on actual projects [10,80]. Contrarily, this paper simulates investor trade-offs and preferences using a real-world scenario and allows conclusions to be drawn about the future investment interests of investors.

Even though initial empirical observations and different studies have clearly indicated the existence of risk heterogeneity among investors, empirical evidence that supports a cross-investor analysis between the same risk factors is scarce [4,50,79]. Based on the results of current research about the differences between investor groups, this paper provides evidence to support the existence of investor-specific preferences for renewable energy investment opportunities.

While the analysis presented herein contributes to the emerging stream of research on professional investor's preferences for renewable energy investments, most of the empirical literature is based on revealed preference analyses of incumbent utilities and excludes appraisal of probable future action in a changing environment. The current research addresses these major downsides and applies choice experiments with two groups of investors (incumbent utilities and institutional investors) as a way of obtaining fresh information about how different levels of risk affect investors' choices and investments into capacity.

### 3. Material and methods

The survey confronted respondents with a set of investment opportunities with the goal of ultimately deriving individual utility

functions in real-time. In contrast to the approach of revealed techniques that build on historical data, this stated preference approach, namely choice experiment, predicts future investment developments by capturing present choices [36,52]. I see particular merit in conducting research based on a stated-preference approach according to the following arguments:

- (1) The object was also to observe the behaviour of new market entrants (e.g. insurance companies, pension funds) with a scarcity of historical data
- (2) A relatively high number of market participants and new entrants are not listed on the stock exchange and / or incumbents and new entrants often operate in other fields, making it difficult to accurately define the influence of renewable energy activities
- (3) The renewable energy market is a highly dynamic market in which past decision-making behaviour can not necessarily predict future decision-related behaviour (e.g. changes in policy design, increasing market and technology experience, economies of scale)
- (4) Accurate valuation of preferences for components of the investment decision (e.g. business models, electricity price risk) is of particular interest for the development of future policy design

First introduced by Kruskal [37] and Luce and Tukey [44] in mathematical psychology, choice experiments rapidly gained popularity in other research fields, including health care [59,64,65], marketing [22–24] and entrepreneurship [53,62,69]. Moreover, the method is commonly applied in the investment and energy investment decision literature [11,20,30,38,46,48,63,66,74,78].

Over the years, there have been numerous further developments of the method. These include full-profile methods such as choice-based conjoint analysis (CBC), rating-based approaches like adaptive conjoint analysis (ACA) and adaptive choice-based conjoint analysis (ACBC) in response to the perceived shortcomings of the previously mentioned. Although rating-based approaches are relatively straightforward in the sense that respondents select between a limited number of attributes, full-profile methods approximate reality more closely as choices are based on complete product portfolios [16,43]. Due to its ability to combine the benefits of both approaches, the latest development, ACBC, was applied in this research endeavour. ACBC mitigates misjudgement of important features [13], but at the same time stimulates interaction while adapting to respondents' choices [28].

#### 3.1. Model specification

By breaking down ACBC to its constituents, its foundations in utility theory, first developed by Bentham, become evident [3]. Further theoretical developments have constructed a more rational and quantifiable definition of utility that includes discrete choice theory and random utility theory [2,32,51]. Among these further developments, Lancaster [39] notes the frequent application of the method in choice experiment literature. As illustrated in Formula (1), Lancaster [39] proposes that the total utility ( $U$ ) of a product (or investment in this case) equals the sum of its attributes' part-worth utilities ( $u_i$ ). In simple terms, an investment opportunity can be broken down into several components (e.g. technology type, business model, partner) that can be represented as a unique value. In reality, however, deterministic part-worth utilities cannot fully explain total utility, leading to a stochastic error term ( $e$ ) as explained in random utility theory [47]. Return, and a bundle of investment attributes, more accurately determine individual choices.

$$U = \sum_{i=1}^m (u_i + e) \quad (1)$$

Part-worth utilities are determined on an ex-post basis through aggregating the individual part-worth utilities of all survey respondents

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