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Risk implications of renewable support instruments: Comparative analysis of feed-in tariffs and premiums using a mean–variance approach

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ABSTRACT

Different support instruments for renewable energy expose investors differently to market risks. This has implications on the attractiveness of investment. We use mean–variance portfolio analysis to identify the risk implications of two support instruments: feed-in tariffs and feed-in premiums. Using cash flow analysis, Monte Carlo simulations and mean–variance analysis, we quantify risk-return relationships for an exemplary offshore wind park in a simplified setting. We show that feed-in tariffs systematically require lower direct support levels than feed-in premiums while providing the same attractiveness for investment, because they expose investors to less market risk. These risk implications should be considered when designing policy schemes.

1. Introduction

To reach their targets for electricity production from renewable energy sources, many countries will have to accelerate deployment rates and increase investment in renewable energy projects. In Europe, annual investment in renewable energy has to approximately double to about EUR 70bn, so that the binding 2020 targets can be reached [1]. As the electricity sector in most European and American countries is liberalised, investments are generally profit-motivated and delivered by private investors reacting to respective financial incentives. A major role of governments with targets for renewable energy is thus to provide adequate incentives for such investments. For this, governments often use financial support instruments such as investment grants, tax breaks, feed-in tariffs and quota obligations with tradable certificate markets. The applied policy instruments shall be effective in achieving the targeted deployment at the lowest possible cost. To provide adequate financial incentives that balance between providing sufficient incentive for investment and avoiding high societal cost from support payments, it is essential that policy makers when designing policy schemes have similar considerations as private investors when preparing investment decisions.

Pure cost-benefit analyses, which are often the basis of policy decisions [2], are usually not sufficient for investors. One reason for this is that cost-benefit analyses only consider net benefit (or return) as key indicator for attractiveness of investment. This one-dimensional perspective can however lead to fatally wrong decisions as it does not inherently consider the risk of investment. This is illustrated in Fig. 1, where project A would be preferred in a cost-benefit analysis due to the highest return, although project B is in fact more attractive as it has the best risk-return relationship.

The recognition that expected return and the related risk are the only two–and equally important–indicators relevant for private investment decisions is a cornerstone of modern portfolio theory [4]. The underlying approach is often referred to as MVP (mean–variance portfolio) approach (or mean–standard deviation approach) as risk and return are represented in the quantitative analysis by the two indicators mean (expected level of return) and variance (of the expected level of return). According to modern portfolio theory, a typical risk-averse investor would always require higher returns for riskier investments. For our analysis this is relevant as some support schemes inherently expose investors to more market risk than others. These support instruments would (all other things equal) consequently require higher direct support levels to compensate for the higher risk. It is from this basis that we start our analysis.

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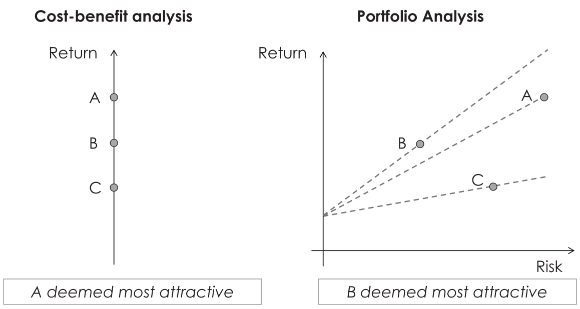

Fig. 1. Diverging conclusions of cost-benefit analysis and portfolio analysis for the same hypothetical projects A, B and C [3].

1.1. Literature review

The MVP approach has been applied in the energy area to a considerable extent. It was first used to optimise fossil fuel procurement in the U.S. regulated electricity industry [5]. The work of Awerbuch [6,7] started a new interest in the field, especially for analyses of optimal generation mixes on national and regional level, including the U.S. [8], the EU [9], Italy [10], the Netherlands [11], China [12], and for combined heat and power in Germany [13]. MVP has also been applied for fuels and electricity in the worldwide transport sector [14].

Awerbuch focused in his work mainly on risk on the cost side, i.e. fossil fuel cost. Arnesano et al. [10] and Jansen et al. [11] have additionally considered risk on the supply side such as risk from uncertain resource availability, which is especially relevant for renewable energies reliant on wind or solar irradiation. Roques et al. [15,16] have pioneered the application of MVP for analysis from the perspective of (private) investors in the electricity sector. They broadened the scope of the analysis considering cost and revenue equally to analyse the full spectrum of incentives for investors.

In energy policy research, risk considerations play an increasing role [17,18]. Different approaches are suggested, which are though mostly based on adding (more) risk elements into current cost-benefit approaches, e.g. by adjusting the discount rates or cost of capital [2,19,20], by calculating a 'risk-adjusted' levelised cost [21], and by using probability distributions in the net present value considerations [22]. Approaches such as the MVP that handle risk inherently seem very suitable for the analysis of energy policy, and especially renewable support, as they give additional insights on the impact of uncertainties and risks for investors and society (as also briefly discussed in Ref. [18]). Despite the interest in applying MVP in research on energy investments on the one hand, and the increasing interest in risk issues by energy policy research on the other hand, MVP has to the author's knowledge not yet been applied for the analysis of energy policy instruments and required support levels. This paper bridges that gap.

1.2. Research interest

The subject of investigation in this paper is to analyse the inherent relationship of risk and return for renewable energy under different support policies. A typical offshore wind project serves as case study, so that impacts on both the private investor (in form of attractiveness of investment) and society (in form of required support to be paid) can be quantitatively analysed in a concrete example. In principle, such analysis could be undertaken for any technology. Offshore wind investment is however a relevant topic in Europe as it has high deployment expectations but still relatively immature markets [23]. The decision on which support policy instrument to implement for offshore wind could be decisive for many countries in reaching their renewable energy targets.

In Europe, we see a recent trend to introduce FIP (Feed-in Premium) schemes for the support of renewable energy, either instead of or next to the previously more dominant FIT (Feed-in Tariff) schemes (seven EU countries have introduced FIP within the last decade [24]). Combinations of FIT and FIT are implemented for example in Spain, where both schemes exist in parallel and producers can choose their preferred scheme [25].

We define FIT as schemes which provide guaranteed prices independent of the market price, where the support can be paid out either as 'fixed FIT' (the producer receives the guaranteed price in exchange for the produced power) or as 'sliding premium FIT' (the producer receives a sliding add-on to his sales on the market). The effect on income stability for investors is similar in both options. This definition of FIT is in line with Refs. [24,26], but in contrast to Ref. [27], who describe the sliding premium FIT of Germany as a FIP. FIP schemes are in our analysis fixed add-ons to market prices. In many applications of FIT and FIP in Europe, the support levels are predetermined by law and are not escalated with inflation [26].

Because of the rising interest in FIP and the tendency of European countries to move from FIT to FIP schemes, we analyse risk implications of these two policy instruments, rather than focus on quota obligation schemes, which have been analysed to quite some extent in the past, e.g. in Ref. [28].

The focus of our analysis lies on the required direct support levels, which diverge because of the different risk exposures of investors. We do not consider indirect societal cost of renewable energies, such as integration or infrastructure cost. We acknowledge that such indirect effects can be substantial, as shown for integration issues in Ref. [29] and for infrastructure investment in Refs. [30,31]. The risks associated with these costs should be considered in analyses that focus on the comprehensive evaluation of support schemes for society.

2. Approach: using mean–variance portfolio theory to investigate support policies

In decision making, the relationship between risk and return is essential. Investment decisions are based on expected average returns (μ), which is almost always subject to risk of deviation over time—This risk is expressed in the variance (σ^2) or standard deviation (σ) of the expected returns [4]. The higher the standard deviation, the broader the spread of possible return outcomes and thus the higher the risk. The deviation is usually in both directions, so the resulting return can be higher or lower than expected. Risk analysis is thus always connected to the willingness and capability of the individual investor to tolerate volatility of an uncertain outcome, and not only about the probability of lower than expected outcomes. In line with modern portfolio theory and most financial analysis, we base our analysis on the assumption that all investors have some sort of risk aversion, meaning that the higher the outcome volatility an investor has to accept, the higher return he expects [4].

An investor can influence some sources of risk more than others (e.g. operations more than weather), either by avoiding risk (e.g. through stringent planning), mitigating risk (e.g. through good project management) or hedging and insuring against the risk. This has been studied extensively, e.g. in Ref. [32] who discusses an optimised way for trading wind energy under uncertainty. Common insurance products for renewable energy projects are mostly targeting technology and project risk [33]. In the context of MVP, hedging is important. Portfolio theory states that any investor can