Investments in Residential Energy Technology –

A Real Option Analysis

Masterarbeit

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1. Introduction

"Energy is essential to our society to ensure our quality of life and to underpin all other elements of our economy. Renewable energy technologies offer the promise of clean, abundant energy gathered from self-renewing resources such as the sun, wind, earth, and plants."(Bull, 2001)

The use of fossil fuels for energy generation has been the subject of repeated discussion in recent years. In the literature, the emission of carbon dioxide that results from the combustion of these materials is considered to be a key variable in the justification of the ever more advanced climate change. Driven by climate change and fossil fuel depletion, an international consensus was made on the necessity of global energy transition from fossil fuels to renewable energy sources (Jeon and Shin, 2014). Energy sources in those considerations can be solar radiation and the resulting heat of the ground or wind power. This renewable energy comprises a multiple of the total energy produced by mankind, but it requires technologies to make use of it (Bull, 2001). Based on the already existing developed and commercialized renewable energy projects (REP) like photovoltaic systems (PVS), wind turbines, hydropower plants and heat pumps (HP), a variety of investment opportunities arises. In the past, these were mostly realized by governments and companies, but increasingly, private investors are also taking a step in this direction. However, the component of financial feasibility is usually the overriding consideration when investing in residential buildings. For the evaluation of such a project, one encounters a multitude of unanswered questions. Regardless of the investors inner drive to decide for such a project, the evaluation is associated with several uncertainties since the investment value is constantly changing. This in return is based on the fluctuating price of energy, consumption uncertainties and various performance factors of the system. It is unclear to what extent these fluctuations of variables influence the value of the REP and furthermore how this can be included in the evaluation. Known investment valuation methods, such as the discounted cash flow (DCF) and with it the net present value (NPV), rather assume that cash flows remain constant throughout the valuation process. These are therefore perfected for evaluating investments over a short period of time and preferably with minimal to no uncertainties (Lee, 2011). This makes valuation relatively uncomplicated and comprehensible, but this simplified view can potentially lead to misinterpretations. At the same time, these methods usually evaluate risk exclusively as a negative influence that fundamentally lowers the investment value. Although if the investor is given a certain room for maneuver, it could be possible that this risk can be used to the investors advantage and even create added value (Brach, 2003). It is therefore questionable whether or to what extent such a method is at all capable of valuing such a complex project (Brach, 2003). In the search for a more advanced valuation methodology that can evaluate such REPs and consider the entirety of uncertainties, the real option analysis has proven to be a suitable tool in the past. The resulting possibility of a flexible investment time is considered as a basis to anticipate the existing risks and to take advantage of possible opportunities.

Two fundamental research questions therefore arise for this thesis:

RQ1: How can the methodology of ROA evaluate investments into renewable energy projects in residential buildings while considering the underlying uncertainties?

and beyond:

RQ2: To what extend do the results differ in comparison to the commonly used technique?

In order to provide an insight into this topic and the defined research questions, this thesis first presents a general introduction to the term of investments which is accompanied by the explanation of the option theory. Furthermore, a consideration of the current state of research is conducted which is presented through the analysis of various publications in this area. After the deriving of the research gap, the presentation of case studies follows to demonstrate directly via examples the impact of the evaluation methodology. For this purpose, the implementation of a photovoltaic system (PVS) and the installation of a heat pump (HP) were explicitly considered. These case studies are implemented in the statistical computing programming language R in order to provide a possibility to perform calculations for different examples in a compromised time. The programming is based on defined functions which can be executed afterwards with other numerical examples. A discussion of the obtained results with the consideration of existing limitations represents in connection with a final conclusion and an outlook for further research the ending of this thesis.

6. Conclusion and Outlook

In order to demonstrate to what extent an evaluation with the help of ROA can be applied to the given case of renewable energy technology in residential buildings, this work has carried out the theoretical implementation and evaluation of REPs. The assumption was made that a potential investor would have the possibility to acquire an option that would allow the implementation of such a REP in a pre-defined time horizon. This option allows an investment in the given period of 10 years but does not force it to be realized at any particular stage. Additionally, the investor was allowed to postpone the investment decision to observe the further course of uncertainties. To illustrate these underlying uncertainties, a case study on the implementation of a PVS was used to examine how these uncertainties are reflected in the investment value. For this purpose, it was assumed that the added value of such a system is generated by the savings in contrast to the conventional purchase of electricity. An investment value was therefore linked to the price of electricity, which is knowingly subject to fluctuations. The costs incurred for such an implementation served as the strike price of the option. The consideration of the feed-in tariff available in Germany and realistic assumptions about the performance of the system under different weather conditions represent a feasible setting. For the case of this PVS, for both a 2-person household and a 4-person household, positive option values could then be predicted in the current period using this option theoretic approach. Simultaneously, by calculating the individual subsequent periods, it became possible to weigh up between the further use of the waiting option and the direct investment possibility, which in the end indicates the optimal investment timings. In addition to this case study, the implementation of a HP was evaluated. Here, a distinction could be made between the selection of different system types, the usage of government subsidies and the existing system to be substituted (gas or oil). In addition to positive option values in the current period and optimal investment times, it was also possible to draw conclusions about the individual influence of the various variables. Basically, it is noted that the defined risk-free rate and the underlying costs for the investment have a significant impact on the option value. However, the influence of the defined percentage fluctuation of the underlying investment value was identified to have a greater influence on the results of the valuation. This was further confirmed by an extension of the HP case study. In this extension, the cost variable was also attributed an uncertainty which resulted in immense costs that nevertheless resulted in a positive option value due to the fluctuation of the underlying investment value.

In order to establish a comparison with the traditional valuation methodology, namely the NPV, this discounted cash flow was also calculated for all implemented REPs using the same data basis. The results obtained for each project yield negative values and therefore led to a non-investment according to the valuation basis of the NPV. Thus, a clear added value for the ROA could be demonstrated and, at the same time, the assumed weaknesses of this classical valuation method could be confirmed. In particular, these can be traced back to the failure to take into account uncertainties and the lack of investor flexibility. Based on the limitations described in this paper, further research should be conducted to provide a better data basis to justify the fluctuations of assumed variables. While various variables were assumed to be fixed in this elaboration, a possible fluctuation of these should be anticipated and recalculations could be performed on even more uncertain variables.