Effective Renewable Energy Policy – Empirical Insights from Choice Experiments with Project Developers

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Abstract

Despite the significant growth in some renewable technologies in recent years, the overall share of renewable power is still low. To overcome the existing barriers and promote expansion of renewable energy power production, public support policy needs to effectively influence the behavior of project developers and investors. There has been substantial policy experimentation and learning over recent years, but how project developers react to certain policy attributes has been a black box so far. This doctoral thesis has opened this black box by conducting a case-study analysis applying a consistent risk-return perspective and conducting two conjoint analyses among European and U.S. solar and wind energy project developers.

This approach addresses several limitations of previous research. First, it follows the various calls to include the investors' and project developers' perspective in energy policy analysis. Second, unlike many previous studies, it analyzes policy measures effectiveness by investigating renewable energy project developers' stated preferences instead of revealed data (e.g., installed capacities). Third, it investigates specific policy factors, which allows breaking down support policy instruments and aggregate measures of risk into individual components and evaluating their specific importance.

The findings show that risk factors (e.g., long administrative processes) are critical in regard to the deployment of renewable energies and might hinder deployment even when one would expect a high level of deployment based on the return related factors (e.g., level of feed-in tariff). The surveyed project developers perceived legal security, administrative process duration and remuneration as the most important policy factors. The thesis further shows that risks need to be compensated with a higher level of support to maintain a country's renewable energy investment attractiveness for project developers. However, in the case of very high risks (e.g., the possibility of corruption), many developers apply non-compensatory decision-making rules when evaluating opportunities and consider very unfavorable attributes as knock-out criteria. Finally, the thesis reveals that preferences between project developers from different geographic regions with comparable investment environments are quite similar, but that there are some differences based on cultural factors, regional barriers for renewable energy project development and support policy familiarity of project developers.

1 Introduction

1.1 Background and Problem Statement

Governments around the world are increasingly adopting policies to promote the deployment of renewable energies. In early 2010, more than 100 countries had enacted some type of policy target and/or promotion policy related to renewable energy (REN21, 2010). On the one hand, renewable energies can help – in combination with other measures such as energy efficiency and electricity grid expansion – to solve two interrelated energy challenges the world is facing: climate change and increase in energy demand. On the other hand, renewable energies bring many new business opportunities in all parts of the value chain by enabling transformative, productive industrial change. Countries that provide more attractive policy schemes will thus attract more investment and will be able to build new industries, technologies and jobs faster (DB Climate Change Advisors, 2010). Examples of such developments are Germany and China.

In the last several years and mainly thanks to government initiatives, there has been a significant growth in some renewable energy technologies. In 2009, renewable energy accounted for 61% (15,904 MW) of all new generating capacity installed in the European Union, with wind power as the most prominent (39%), gas as the second most prominent (26%) and solar PV (photovoltaic) as the third most prominent (16%) power technology (EWEA, 2010a). Nevertheless, the overall share of renewable energy in global electric power supply, i.e., 18%, is still low (REN21, 2010). Reasons for the low absolute levels of renewable energies market penetration are manifold and interlinked, but can roughly be classified as economic, regulatory and social in nature. The main economic obstacles are the accounting and financial assessment methods used for energy projects, which are biased in favor of riskier fossil alternatives, the non-internalized external costs of conventional technologies and the high subsidies those technologies received and still receive (Awerbuch, 2000; Beck, Martinot et al., 2004; Dinica, 2006; Sovacool, 2009b). Regulatory barriers include administrative hurdles like strong environmental regulations and long, bureaucratic and nontransparent authorization and permitting procedures; obstacles to grid access like insufficient grid capacity and long, nontransparent, costly procedures for grid connection; and support policy instability with sudden policy changes and stop-and-go situations (Wiser and Pickle, 1998; Beck, Martinot et al., 2004; Haas, Eichhammer et al., 2004; Mitchell, Bauknecht et al., 2006; OECD/IEA, 2008; Sovacool, 2009b; Gross, Blyth et al., 2010). Social impediments include public apathy largely resulting from misinformation about the need for renewable energy technologies; path dependencies as in the case of large power utilities who are most familiar with large, centralized power plants and therefore are uncomfortable with decentralized renewable energy projects; psychological issues like the opposition of local stakeholders based on the "Not-In-My-Backyard (NIMBY)" syndrome; and deeply held values related to consumption, abundance, trust, control and freedom that shape many attitudes toward energy (Krewitt, Simon et al., 2007; Wüstenhagen, Wolsink et al., 2007; Stenzel and Frenzel, 2008; Sovacool, 2009a; Sovacool, 2009b).

To overcome these barriers and to promote the expansion of renewable energy, support policy measures play an important role. For a long time, the overarching objective of renewable energy support policies has been to focus on return factors by addressing the economic barriers. Cost per unit of output has been used in assessing the rationale for and determining the level of policy interventions. A broad strand of literature assesses which promotion scheme has delivered expected results. It has been shown that well-designed feed-in tariff systems compare favorably to other financial support schemes both in terms of effectiveness and efficiency (Held, Ragwitz et al., 2006; Mendonça, 2007; Couture and Gagnon, 2010). Interestingly however, seemingly similar policy schemes at comparable levels of financial support have led to significantly different outcomes in different countries. For example, Germany, Spain and Greece all offered feed-in tariffs of approximately 45 ct/kWh for solar electricity generators in 2007, but newly installed capacities in that year ranged from 1.135 MW in Germany to 505 MW in Spain to just 2 MW in Greece (Sarasin, 2009). This indicates that focusing on costs and economic barriers by financial support measures is not sufficient for the promotion of renewable energy production.

Lately, the relevance of regulatory barriers, and the importance of risk in general, has been recognized in the academic literature (Mitchell, Bauknecht et al., 2006; Blyth, Bradley et al., 2007; Lewis and Wiser, 2007; Gross, Blyth et al., 2010; Komendantova, Patt et al., 2010). At the same time, there has been a call to include the perspective of investors and project developers in the analysis of energy policies (Birol, 2003; Dinica, 2006; Gross, Blyth et al., 2010; Menichetti and Wüstenhagen, 2010). Indeed, investors and project developers are key actors in the deployment of renewable energies because they effectively build the renewable energy capacities. Thus, the inclusion of their perspective when designing a support policy makes sense as they actually decide whether a policy framework is attractive to spur development activities and thus effectively convert the regulatory environment, financial incentives and the available investment funds in the market into installed capacities. As in any investment context, investment decisions for renewable energy projects are made based on an evaluation of risk and prospective returns (Blyth, 2006). As a result, considering return factors is certainly useful in deciding whether support is necessary, but is not sufficient to determine the necessary amount of support (Gross, Blyth et al., 2010).

While there seems to be an emerging consensus that an essential feature of effective policies is that they succeed in reducing regulatory barriers and thus risks for companies building or investing in renewable energy plants, there is relatively little empirical evidence on the most important risk factors and little is known on how project developers weight different risk and return factors. Many past studies conducted a comparative ex post assessment of support schemes often using case studies (e.g., Gouchoe, Everette et al., 2002; Langniss and Wiser, 2003; Bird, Bolinger et al., 2005; Del Río and Gual, 2007), but valid results on the relationship between specific attributes of policy risk and investment outcome and how financial support measures compare to regulatory, risk mitigating measures are difficult to find as there are only a few cases where significant levels of new renewable energy capacity have been achieved. Thus, the potential value of specific policy risk mitigation measures is uncertain.

It is, however, exactly this kind of information that policy-makers need for effective policy design. The critical questions are which risks are most important to project developers, and how important are they; how do financial support measures compare to regulatory measures mitigating risks, either individually or in combination; how much money is required to achieve a certain impact; etc. However, such an ex ante evaluation of policy interventions is difficult. This thesis aims at providing answers to these questions by analyzing policy preferences of renewable energy project developers.

1.2 Objectives and Research Questions

This paper-based dissertation is built on the assumption that in order to optimize policy schemes and to promote investments in renewable energies, countries need to identify the barriers for renewable energy project developers and investors and, based on this information, establish attractive conditions that overcome those hurdles. The overall aim of this thesis is to contribute to the deployment of renewable energies by investigating renewable energy project developers' policy measure preferences. A project developer perspective is chosen because they are key actors in the deployment of clean technology.

This thesis aims at contributing to research and praxis. It addresses three research gaps in the energy policy literature. First, this study takes the project developers' perspective and thus answers the various calls for the inclusion of the investors' and project developers' perspective in the energy policy analysis. Second, it investigates specific policy factors, which allows breaking down support policy instruments and aggregate measures of risk into individual components and evaluating their specific importance. Third, it provides an ex ante assessment of potential effects of specific policy measures by assessing project developers' preferences. These preferences provide real-time information about how different policy factors affect today's investments, and hence tomorrow's installed capacity.

This thesis intends to contribute to the energy investment decision literature, first, by applying discrete choice theory to investment decision-making of renewable energy project developers. This allows the examination of different parts of the decision-making process and the investigation of the importance of specific factors. Second, this thesis collects data as project developers make decisions rather than surveying developers about past decisions. Retrospective accounts often produce biased results as respondents may be unwilling or unable to recall their decision-making processes (Lohrke, Holloway et al., 2010b). Third, the investigation of the investment behavior of project developers (early-stage investors) adds to the energy investment decision literature as previous studies mostly focused on a restricted group of investors, namely venture capitalists.

By applying conjoint analysis, this doctoral thesis aims at revealing the potential of this method to contribute to effective renewable energy policy design. The emphasis on conjoint analysis has been chosen for several reasons. Among others, this method makes it possible to investigate specific factors in the decision process and provides real-time information about preferences, which obviates the possibility of problems regarding 1) the lack of revealed data analysis in the young and dynamic renewable energy market, and 2) post hoc revisionism resulting from social desirability, faulty memory or the inability to articulate complex decision processes in the case of surveying respondents about past decision (Shepherd & Zacharakis, 1997).

Contributions to praxis are intended mainly in the field of policy making. This thesis aims at giving insights into project developers' preferences because they are major market actors and use policy measures and available market investment funds to create real things in the world, i.e. power generating plants. Knowledge about preferences of project developers and how they trade off different support and regulatory measures will help policy-makers to define policy priorities. Doing preference simulations, this thesis aims at providing an ex ante analysis tool to policy-makers. This approach makes it possible to estimate the impact of certain measures in a given environment.

Rigor and relevance are of high importance for this dissertation project. To assure relevance, research questions and the design of the surveys are based on literature review and expert interviews. Rigor was especially high on the agenda when designing and evaluating the surveys. They were designed carefully and only released after a pretest with project developers, renewable energy researchers and methodology experts.

This thesis aims at answering the following five research questions:

1. **How do different policy risk and return factors influence the deployment of photovoltaic?**

Currently, PV contributes only very little to power production even in sunny countries in the Mediterranean region, whereas the PV industry is booming in Germany, a much less sunny country. This reveals that the solar market is still not self-sufficient and is dependent on effective solar energy policy measures. Surprisingly however, installed PV capacities are even low in the Mediterranean countries that provide similar or even higher support levels than Germany. As a consequence, it is of high value to investigate the regulatory barriers, i.e., the role of different policy risk factors in the deployment of PV and to study their importance compared to return factors.

Study 1 (chapter 2) analyzes how specific policy risk and return factors are linked to installed PV capacities by looking at the policy development and the deployment of PV capacities over time. Applying a risk-return perspective, the study compares the PV policy of Spain and Greece to the German situation and especially the feed-in tariff provided under the Renewable Energy Sources Act (EEG). The risk-return perspective reflects the two dimensions of project developers' reaction to policy measures and provides the basis for the following quantitative studies.

2. **How important are various policy attributes in influencing the decision of a renewable energy project developer to build a project?**

The PV industry plays an important role in the transition to a renewable energy based system. PV and wind energy project development companies that operate on a multinational level transfer products that are successful in their home markets to markets worldwide and thus are important transfer agents (Jacob, Beise et al., 2005). A project developer will, however, only enter a market which provides promising framework conditions. As a result, the analysis of preferences of project developers provides valuable insights about the effect of policy measures.

To date, the literature about effective policy design has been limited in scope as there are only a limited number of scientific publications that assess the implications of policy choices on project developers (Wiser, Pickle et al., 1997; Bird, Bolinger et al., 2005; Johnston, Kavali et al., 2008) or specifically take the perspective of investors or project developers (Wiser and Pickle, 1998; Masini and Menichetti, 2010b). Wiser & Pickle (1998) for example analyzed, by means of case studies, the influence of renewable energy policies on the financing process and on financing costs. In doing so, they provided insights into the important nexus between renewable policy design and project financing.

Studies 2 and 3 (chapter 3 and 4) conduct two conjoint analyses among PV and wind energy project developers and quantify the value of different policy attributes. Doing so, they complement the country-level case study analysis of the first paper with a firm-level analysis. A country based analysis of the effects of policy measures on installed capacities is limited to an aggregated, ex post assessment of what has influenced the investment decisions of PV market players. Studies 2 and 3 also complement the qualitative case study analysis (study 1) with a quantitative study that quantifies the importance of the different risk and return factors and how project developers trade them off.

3. What is the policy risk "price" or "premium" that developers request in order to take the burden of a certain barrier?

For policy-makers, it is of high value to understand how project developers trade off different risk and return factors and for how much compensation they ask in case of higher risks. This allows policy-makers to quantify and prioritize the influence of specific policy measures on investment behavior, to focus on the most effective measures and thus realize the design of an efficient support policy.

4. Given the current investment environment in a given country, which measures provide the biggest value to developers?

General insights into the value of financial and regulatory measures for project developers are certainly of high value, but the value of a specific measure may vary strongly depending on the current investment environment in a given country. In some countries, faster administrative processes might bring the highest increase in attractiveness for developers, whereas better grid access conditions or an increase in remuneration would be valued most in other countries. Study 3 conducts three base case preference simulations to indicate which measures might be of highest priority in three specific areas.

5. What preference differences exist between renewable energy project developers active in different regions?

The geographical scope of this thesis is limited to a regional analysis of Europe and the U.S. An investigation of regional preference differences allows one to determine the extent to which the results of the policy factor preference analyses are valid on a country- or state-level basis and for other regions with similar investment environments but out of the scope of this thesis.

On the one hand, preferences could be very similar between project developers of different regions because the impact of cash flows and risks resulting from the different policy factors on project profitability and project quality should be in the same order of magnitude in different regions. Also, the renewable energy project business is a very international business and developers are often active in different countries. If preferences between different regions are very similar, one can assume that the results of this doctoral thesis are valid for other regions and countries that provide a similar policy framework. (This does not necessarily include developing countries which are confronted with certain risks not taken into consideration in this thesis.)

On the other hand, developers might have region-specific preferences due to their own prior experiences, their prior familiarity with various policy instrument or cultural factors. Developers who are confronted on a daily basis with difficult permitting procedures might have a strong preference for shorter administrative process durations. Developers who are familiar with an investment cash grant support policy scheme might prefer cash grants to other financial support schemes, while developers in regions with a feed-in tariff might be more in favor of this kind of support scheme. A possible cultural factor that influences developers could be risk propensity, e.g., in cultures with a lot of corruption, people are used to it and have thus learned to cope with this risk. Other cultural factors are the nature of financial investment terms, e.g.., some cultures might prefer long-term investments involving few risks, while other cultures might prefer riskier short-time investments and a higher investment discount rate. If preferences differ strongly depending on the region, international policy learnings need to be implemented carefully by taking into account the preference differences.

Study 3 provides insights into this issue by analyzing preference differences of wind energy project developers active in Northwestern and Southeastern Europe and in the U.S.

1.3 Theoretical Background

The diffusion of innovation theory provides the theoretical framework for study 1 and theoretically motivates the role of policy-makers as key actors in the diffusion process. The development of the renewable energy market can be interpreted in terms of the diffusion of innovation (Rogers, 1995) in the way that Villiger et al. (2000) who described the market penetration of green product innovations in the food, clothing and electricity sectors. Similarly, study 1 describes the PV development market in Germany, Spain and Greece divided into four market diffusion phases: introduction, early growth, take-off and maturity.

Currently, the development of the renewable energy market is restrained by the present energy system. This system dependency is one of the major barriers of an energy system change (Shackley and Green, 2007). When the market fails to achieve socially desirable objectives (as in the case of the transformation to a sustainable energy system), there should be an incentive for potential adopters (Rogers, 1995). The government should intervene in the role of an “agent d'animation” (Maskell and Kebir, 2006) and provide such incentives. Thus, according to innovation system literature, “government regulation […] is one of the factors stimulating innovation” (Beerepoot and Beerepoot, 2007, p. 4812). This doctoral thesis focuses on government intervention through financial support measures (i.e., subsidies, feed-in tariffs) and the regulatory framework.

The main theoretical framework underlying this thesis (i.e., studies 2 and 3) is linked to the analysis of renewable energy project developer preferences and based on the discrete choice theory. As a result, this thesis is built on the assumption that project developers make their choices based on their own individual preferences. In the following, the different foundations underlying the preference investigation are briefly explained (Ben-Akiva and Lerman, 1985; Louviere, Hensher et al., 2003; Hensher, Rose et al., 2005; Train, 2009).

Microeconomic consumer theory provides the foundation for the discrete choice theory. Consumer theory analyzes the economic decisions, especially the consumption decisions, of private households. It states that a consumption decision is based on a cost-benefit comparison of the different product alternatives and that the consumer chooses the product that maximizes his utility. The theory provides the means to transform assumptions about consumers' preferences into a demand function. Lancaster (1966) advanced the consumer theory by indicating that products can be considered as bundles of attributes and that the utility of a product is the sum of the part-worth utilities of its attributes. This microeconomic consumer theory view of demand is appropriate to situations where the feasible choices are continuous. However, where choices are a selection of one out of a finite set of attributes (as is the case in this thesis), discrete choice theory is appropriate. Discrete choice theory uses the concept of the rational consumer, but it differs from consumer theory in that it works directly with the utility function, instead of deriving demand functions.

It is not possible to completely describe any product’s utility in terms of its attributes; there will always be some unknown or intangible characteristic which may also provide utility. As a result, the other underlying foundation of discrete choice theory is random utility theory (Mansky, 1977), which allows the direct utility function of a person to be broken down into observable (deterministic) and unobservable (stochastic) parts. The utility is thus not an apparent value but an unobservable random variable. This probabilistic approach accounts for randomness in the choice behavior.

This doctoral thesis is built on the assumption that renewable energy project developers evaluate the different factors influencing their location choice according to this concept. They do not choose among different products but among policy frameworks. I argue that the policy framework of a country can be described as a bundle of attributes, analogous to a product with multiple attributes. Renewable energy project developers choose the location for their projects by looking for the country with the policy framework that provides the highest utility. As in the case of a choice among products, when choosing among policy frameworks, there is an inevitable trade-off between the different attributes, and any attribute change influences the attractiveness of the respective country for the project developer. A higher level of return, for example, increases the utility and thus the attractiveness of a country whereas higher policy risks decrease the country’s utility.

1.4 Research Framework

The research framework for the analysis of project developers’ policy measure preferences follows the discrete choice model as explained above. According to this model, the project developer faces a choice among a set of options that can be described by different factors. Figure 1.1 illustrates the research framework. The renewable energy project development decision (i.e., the dependent variable) is influenced by various factors (i.e., the independent variables) which can to a large degree be divided into risk and return factors. Some of these factors can be influenced by policy-makers (highlighted gray in Figure 1.1) and are, as mentioned earlier, the focus of this thesis. They include all aspects that involve some sort of government action, or at least the possibility of government action regarding renewable energy policy issues (Butler and Joaquin, 1998). This thesis does not include policy risks that arise from societal sources like demonstrations and interstate sources like gas and oil price insecurities or cross-national policy requirements (Burmester, 2000; Brink, 2004; Stosberg, 2005; Al Khattab, Anchor et al., 2007).

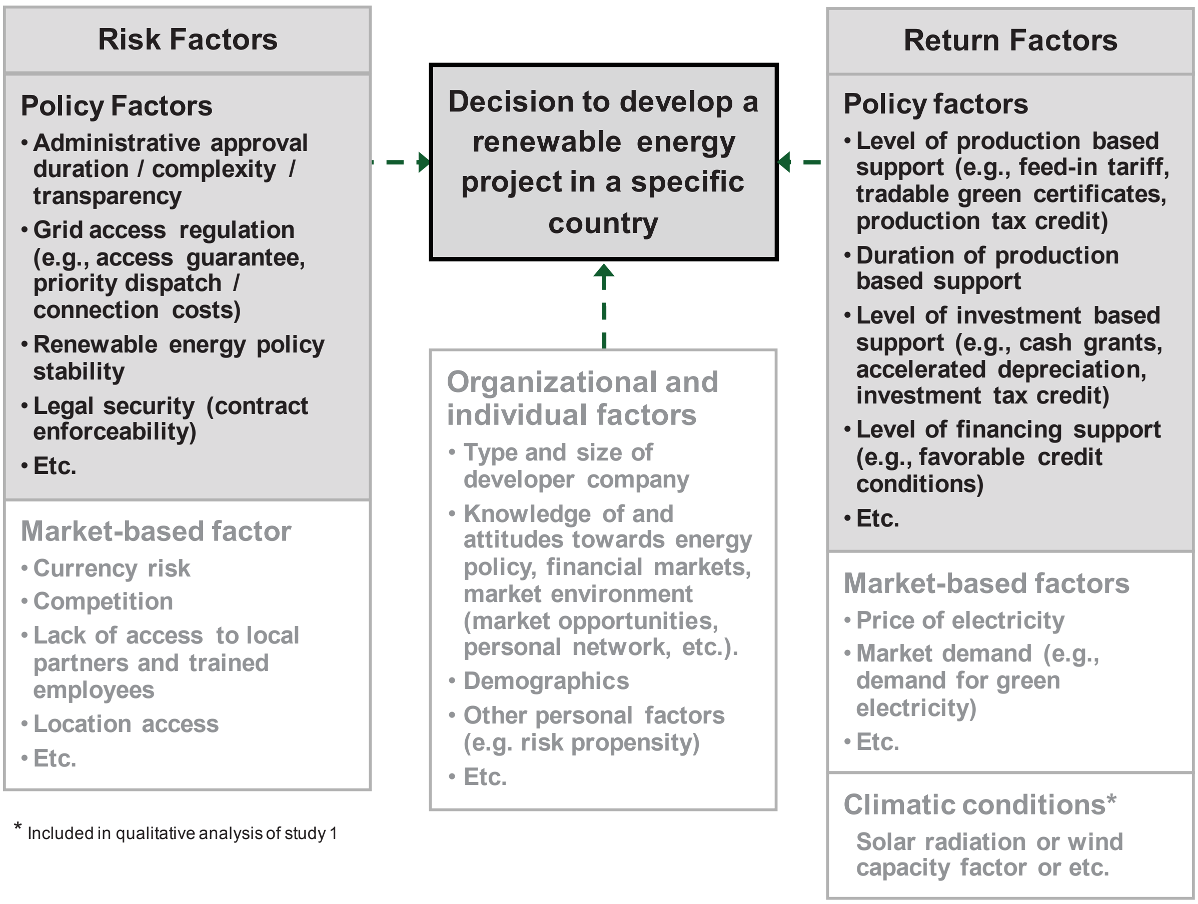

Figure 1.1: Research framework: Factors influencing decision-making for development of renewable energy projects (not exhaustive)

Climatic conditions are kept constant in the developer preference analyses. They are however included in the qualitative case study analysis of study 1. Market-based factors are not in the scope of this thesis, although some relevant market-based variables are included implicitly (e.g., price of electricity is included in the attribute remuneration of study 3).

1.5 Methodological Approach

This thesis applies a mixture of qualitative and quantitative methods. The main method applied is conjoint analysis, with particular emphasis on stated preference data investigation. Study 1 applies a case study design while gathering information through a survey and literature review. Studies 2 and 3 apply a two step approach, starting with qualitative expert interviews which provide the basis for the quantitative conjoint analysis.

The emphasis on conjoint analysis was chosen for several reasons. First, the stated preference design addresses some of the challenges of doing an analysis of revealed preferences in an early-stage growth market, such as the absence of sufficiently long time series and the possibility that ex post analyses might systematically come too late. Second, conjoint analysis makes it possible to break down policy framework choices into underlying respondent preferences for specific stimuli (e.g., policy attributes) (Lohrke, Holloway et al., 2010b). This allows disentangling the importance of different policy attributes to explain outcomes such as installed capacity and provides information about which measures need to be implemented to reach specific policy goals. Third, this approach provides insights into the decision-making process of important market players and thus tomorrow's installed capacities (Usher, 2008). Fourth, this method makes it possible to indirectly estimate preferences by assessing respondents' "theory of use", which has important advantages in comparison to a direct survey assessing respondents' "espoused theories of action". If directly asked, people often have difficulty accurately describing what they actually do (Dorn and Huberman, 2005); they might avoid talking about or not even recognize potential mistakes or irrational behavior or they might lack insight into or simply not remember their own decision-making behavior (Golden, 1992; Zacharakis and Meyer, 1998).

Conjoint analysis methods are based on work in the sixties by the mathematical psychologists and statisticians Luce and Turkey (1964), and introduced in marketing research in the early 1970s (Green and Srinivasan, 1990; Orme, 2007b). Over time, the use of conjoint analysis has spread from marketing research and has become an accepted approach in a wide array of research communities (Louviere, Hensher et al., 2003). For example, it has been used to investigate entrepreneurs' decision-making processes, including the examination of venture financing issues (e.g., Riquelme and

Rickards, 1992; Muzyka, Birley et al., 1996; Shepherd and Zacharakis, 1999; Franke, Gruber et al., 2006; Lohrke, Holloway et al., 2010b). To the author's knowledge, conjoint analysis experiments have not before been proposed or applied in renewable energy policy design. However, the discussion above suggests that such an approach is potentially useful and can add relevant new elements to the discussion about renewable energy policy effectiveness. Along the same lines, Netzer et al. (2008) recommend that policy-makers should use more conjoint analysis.

1.6 Doctoral Thesis Outline

Table 1.1 gives an overview of the three studies conducted in the framework of this thesis. Chapter 2 (study 1) is a qualitative case study analysis. The following two chapters (studies 2 and 3) investigate renewable energy project developers' preferences using conjoint analysis. The three studies have different renewable energy technology (solar PV and wind energy) and regional (Mediterranean countries, Europe and United States) foci and investigate different policy framework characteristics (cf. Table 1.1). At the end of each study in the section "Supporting Material", the questionnaires and choice experiments are attached.

Chapter 2 analyzes the effect of solar energy support policy measures on the deployment of installed PV capacities by applying a country-level case study design. The study aims at identifying solar energy policy characteristics that enhance the diffusion of PV capacities. For this purpose, it compares the PV support policies of two Mediterranean countries – Spain and Greece – with the German policy and installed PV capacity development. The results indicate that the deployment of installed PV capacities cannot be explained solely by return factors (such as solar radiation conditions, financial incentive level and duration), and that risk factors (such as permitting process duration and renewable energy policy stability) are also very important. This brings up the questions of what the main risk factors are and how important they are in relation to the return factors.

Chapter 3 follows up on the conclusions of the qualitative study of chapter 2 with a quantitative study. Based on the results of the previous chapter, this chapter analyzes and quantifies different risk factors in relation to renewable energy policy. Using conjoint analysis, it investigates investment decision criteria of PV project developers

Table 1.1: Thesis overview on geographical scope, target group, technology, method, research questions and analyzed factors per chapter

	Geographical Scope	Target Group	Technology	Method	Research Questions	Analyzed Policy Factors
1	Effective Deployment of Photovoltaic in Mediterranean Countries – Balancing Policy Risk and Return					
	Germany, Greece, Spain	(Installed solar PV capacities)	Solar PV	Case studies (Qualitative pre-study)	- Which are the decisive drivers and barriers for PV regarding the installed PV capacities?	Return Factors: - Level of feed-in tariff - Duration of support - Solar radiation Risk Factors: - Solar energy policy stability - Promotion cap - Administrative process duration and complexity
2	The Price of Policy Risk – Empirical Insights from Choice Experiments with European Photovoltaic Project Developers					
	Europe	European solar PV project developer	Solar PV	Adaptive Conjoint Analysis (ACA)	- Which are the solar energy policy related factors influencing the location decision of PV project developers? - What is the policy risk "price" or "premium" that they request in order to take the burden of a certain barrier?	Return Factors: - Level of feed-in tariff - Duration of support Risk Factors: - Expected time until support cap will be reached - Administrative process duration - Solar energy policy stability
3	Policy Levers for Wind Development – Comparison of Preferences of European and U.S. Wind Project Developers					
	Europe, U.S.	U.S. and European wind project developers	Wind energy	Adaptive Choice Based Conjoint (ACBC)	- How important are various policy attributes in influencing the decision of a wind project developer to build a project? - Given the current investment environment in a given country, which measures provide the biggest value to developers? - How do preferences differ between northwestern European, southeastern European and U.S. project developers?	Return Factors: - Level of total remuneration - Credit financing - Investment cash grants Risk Factors - Administrative process duration - Legal security - Grid access

in regard to the solar energy policy. Specifically, it aims to empirically examine the influence of certain aspects of policy risk on the decision of a PV project developer to invest in a given country and to empirically measure the "price of policy risk", i.e., project developers' willingness-to-accept certain policy risks. This allows policy-makers to make a more conscious trade-off between the level of feed-in tariff offered and the reduction of important policy risks for project developers, ultimately leading to more efficient renewable energy support policies.

Chapter 4 investigates wind energy project developers' preferences in Europe and the U.S. The chapter argues that, irrespective of the main financial support scheme (feed-in tariff, quota, cash grants, etc.) policy-makers can create value for the wind markets by assisting in financing, streamlining administrative application procedures and creating reliable grid access regulations. The study examines the importance of different regulatory and financial support measures and their impact on wind energy project developers' investment choices. It provides insights into how project developers trade off different conditions and to what extent the attractiveness of a certain policy framework would increase through the change of specific conditions. Further, it investigates whether there are preference differences between project developers active in different regions (specifically U.S., Northwestern and Southeastern Europe).

The last chapter discusses the results of the three studies and provides recommendations for policy-makers and research. Further it outlines the theoretical, methodological and practical relevance of this thesis, certain limitations and further research possibilities.

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2 Effective Deployment of Photovoltaics in the Mediterranean countries: Balancing Policy Risk and Return[1]

S. Lüthi (2010)

Abstract

Although the Mediterranean region is blessed with abundant solar resources, photovoltaic energy currently represents a very small share of power production. In Germany however, a much less sunny country, the photovoltaic (PV) industry is booming. This country has become a front runner in the adoption of PV because of effective policy incentives. Based on a cross-case study analysis of the German, Spanish and Greek PV markets, this paper investigates factors determining the effectiveness of PV policies. This analysis shows that, above a certain level of return, risk-related factors (such as policy instability and administrative hurdles) play a more important role in influencing investment decisions than return-related factors (such as the level of a feed-in tariff).

Keywords: Support policies; PV systems; Policy effectiveness; Policy risk; Feed-in tariffs.

[1] Chapter 2 is referred to as study 1 in this doctoral thesis.
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2.1 Introduction

The transition to a sustainable energy system based on renewable energy sources is of high importance for various reasons. First, reducing the use of fossil fuels has important environmental and health benefits. Second, energy dependence and conflicts around scarce energy resources threaten global security, and third, the development of renewable energy markets and the creation of new industries create substantial economic opportunities.

A promising energy source of the future is solar energy. In regard to photovoltaic (PV), thanks to strong financial incentives by national and local governments (Jacob, Beise et al., 2005), countries such as Germany have become front runners in the adoption of PV. In addition, solar resources are abundant, especially in sunny parts of the world where grid parity is expected to be achieved very soon (e.g., Southern Italy or parts of California (Sutterlüti, 2008)).

Despite these advantages and high growth rates, the transition is happening slowly and absolute levels of PV market penetration are still modest. The barriers slowing down this transition process are diverse, but to a large extent related to the current higher cost per kWh produced. PV is still an early-stage technology and the transition from central to distributed power production implies transition cost. The cost disadvantage of PV technology is also influenced by subsidies for conventional, non-renewable energy sources and a lack of internalization of external costs resulting among others from air pollution. Further, the investment profile is different compared to competing technologies (i.e., higher initial cost, lower operating cost and lower fuel price risk). Other barriers to diffusion of PV are related to path dependencies (e.g., market power of incumbent energy firms) and cognitive factors (e.g., valuation methods that favor large-scale power plants).

Public policy can play an important role in overcoming these transition challenges, especially by providing financial incentives that lead to accelerated technology development and deployment, hence paving the way towards grid parity. The overarching objective of such policies has been to encourage PV by improving economic conditions. More specifically, policies should ideally include financial incentive schemes which provide seed and start-up funding until a technology reaches maturity. Also, such policies should strive for internalization of PV's external benefits (Sijm, 2002).

Because of its high level of solar radiation, the Mediterranean region is a particularly promising target market. In many of those countries, solar water heaters have already achieved significant levels of market diffusion today. Israel, Cyprus and Greece, for example, are among the leading countries in this sector worldwide (Weiss, Bergmann et al., 2007), and since September 2006, Spain has a solar thermal obligation for new buildings (EREC, 2007). The share of solar power production is however still very low. Whereas Spain and Italy are on track to change this, countries like Greece, Portugal and Cyprus are still at the very beginning of PV deployment.

This paper aims at the description of policy risk factors which should be taken into account in the design of effective PV policies and financial incentive schemes. For this purpose it compares the PV support policies of two Mediterranean countries – Spain and Greece – with the German situation and especially the feed-in tariffs provided under the Renewable Energy Sources Act (EEG), which has been perhaps the most effective promotional policy for renewable energy (Menges, 2003). The paper goes beyond prior research in two important respects. First, it moves from cross-sectional, static policy analysis to a dynamic approach, looking at the policy development process and the deployment of PV capacities over time. Second, it applies a consistent risk-return perspective on PV policies, thereby pointing to the two dimensions of investor reaction to such policies.

The paper is structured as follows: The next section provides a literature review, presents the conceptual framework and describes the methodology of this study. Sections 3 to 5 present case studies from Germany, Spain and Greece. The last section draws conclusions for the design of an effective PV policy and outlines further research questions.

2.2 Literature Review, Conceptual Framework and Methodology

2.2.1 Literature Review

Various types of incentive schemes are used to promote the generation of electricity from renewable energy sources (RES-E). Such schemes may focus on quantities (defining national targets and setting up bidding systems, or quota systems providing for green certificate trading) or focus on price (providing an investment subsidy or grant, or a generation-based feed-in tariff) (Menanteau, Finon et al., 2003). In Europe, the feed-in tariff system has been shown to be the most effective instrument to promote PV, notably to kick-start national PV markets (Sijm, 2002; Del Río and Gual, 2004, 2007; Mendonça, 2007). In the longer term, however, such a system may become hard to sustain as it may suffer from some major drawbacks: when the generation by PV accounts for a significant share in total power production, a system of feed-in tariff tends to be costly, unless tariffs are significantly decreased over time (Sijm, 2002; Del Río and Gual, 2004).

Previous studies revealed that poorly designed and inconsistent policies can hamper PV market growth (Wiser and Pickle, 1998; Menz, 2005). A key element of an effective PV policy is to provide planning security (Wiser and Pickle, 1998; Bustos, 2003; Del Río and Gual, 2007; Mendonça, 2007). Therefore, policies should guarantee a fixed tariff for a sufficiently long period of time (e.g., 15–20 years (Mendonça, 2007)). In general, the tariff should be higher than the marginal costs of generation (in order to ensure a sufficient return on investment); however, if budget constraints do not allow to meet this requirement, a smaller but reliable incentive is better than stop-and-go policies (Del Río and Gual, 2007). Another important feature that has contributed to continuity is the fact that the cost of financing feed-in tariffs is borne by all electricity customers and not funded through government budgets (Mendonça, 2007). Further, the tariff should decrease over time to provide an incentive for technological learning (Schott, 2006). Guaranteed access to the national grid (Del Río and Gual, 2004; Mendonça, 2007) and the establishment of clear and short administrative processes are important in developing investor confidence (Bustos, 2003; Mendonça, 2007).

Whereas studies about the Germany RES-E policy development are abundant (e.g., Stryi-Hipp, 2004; Lauber and Toke, 2005; Jacobsson and Lauber, 2006a; Weiss, Orthen et al., 2006; Wüstenhagen and Bilharz, 2006b; BMU, 2007a, 2007b), there is a lack of analyses of Mediterranean countries' renewable energy policies. Despite its favorable resource situation, the current PV market and policy environment of these countries has scarcely been reflected in the academic discussion. There are only few studies that examined the situation of Spain (Bustos, 2003; Del Río and Gual, 2007; Mendonça, 2007) and Greece (Tsoutsos, Mavrogiannis et al., 2004). This paper aims to fill this gap in the literature. It can draw from some of the contributions from EU-funded applied research projects addressing the current PV support situation in the Mediterranean region. The following projects have devoted at least one part to PV policies: Green-X looked at optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market (Huber, 2004); RE-Xpansion analyzed and compared incentive mechanisms for RES-E in the European Union (EWEA, 2005); OPTRES assessed and evaluated the RES-E support schemes in the European electricity market (Ragwitz, Held et al., 2007); and REMAP is developing an action plan for high-priority renewable energy initiatives in the Southern and Eastern Mediterranean area (REMAP, 2008).

2.2.2 Theoretical Framework

The development of the PV market can be interpreted in terms of the diffusion of innovation. The diffusion of innovation in social systems can be described as following a sigmoid curve (cf. Rogers, 1995). Villiger et al. (2000) extended the phases of market diffusion to describe the market penetration of green product innovations in the food, clothing and electricity sectors (Figure 2.1). According to their terminology, PV market development can be divided into four phases:

1. **Introduction**: PV is available on the market.
2. **Early Growth**: The market share is increasing slowly but still far from sustainable growth.
3. **Take-Off**: PV becomes a profitable business with strong growth rates.
4. **Maturity**: Grid parity is reached.

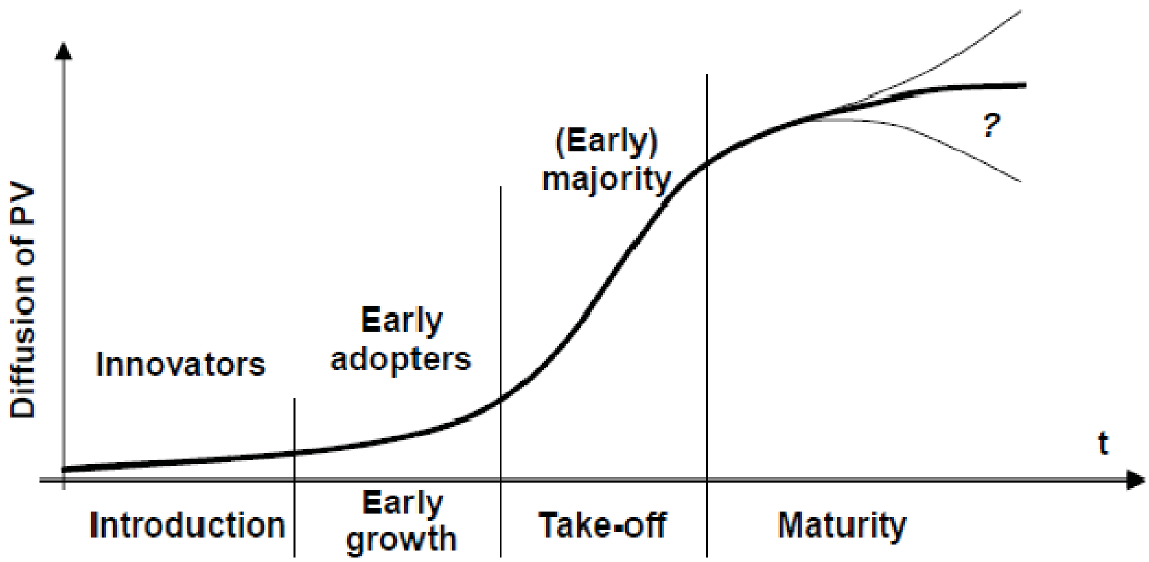

Figure 2.1: Phases of PV diffusion (adapted from Villiger et al. (2000))

The following case studies from Germany, Spain and Greece describe the development of the PV market along these phases of diffusion. Each country is currently in a different phase: Germany is in the take-off, Spain is in the early growth and Greece is in the introduction phase. Since none of the markets has evolved to full maturity yet, the following analysis is clearly limited by available information especially regarding most recent and future developments.

2.2.3 Methodology

The diffusion of PV can be measured in various ways: installed capacity, number of renewable energy businesses established or jobs created, amount of energy produced, measurement of performance relative to program goals, etc. (Gouchoe, Everette et al., 2002). This study analyzes installed capacities. Since latest data are not always easily available, publicly available data was complemented with expert interviews and a literature review. This also provided additional qualitative data on country-specific factors.

The case study research design fits well to the study's aim. This approach involves empirical research in which a contemporary phenomenon is studied within its real-life context, whereby the boundaries of the phenomenon and the context are not clear and evident, and where a number of sources of information are used (Yin, 1994).

Contextual information was gathered through a survey conducted by the author among the partners of the EU FP 6 project DISTRES (promotion and consolidation of all RTD activities for renewable distributed generation technologies in the Mediterranean region). Fifteen renewable energy experts from nine countries completed the questionnaire that followed a two-stage approach. The first part aimed at providing an overview of the currently implemented and planned financing schemes as well as the evaluation of their effectiveness and efficiency by the renewable energy experts. The second part provided detailed information about each currently implemented financing scheme: promoters, target group, funding source, installation conditions, financing details, etc. Additional information for the case studies was gained through data analysis, expert consultations and a literature review including academic and solar energy industry journals, policy documents and reports of research funded by the European Commission.

The paper focuses on the situation of the two Mediterranean countries Spain and Greece. The German case is taken as the benchmark. Since the development of the German PV market and policy environment is relatively well documented in the literature, this case is presented in a rather condensed way here.[2]

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[2] For more details, see: BMU (2007a, 2007b); Weiss (2006); Jacobsson and Lauber (2006a); Wüstenhagen and Bilharz (2006b), Lauber and Toke (2005); Stryi-Hipp (2004).

Each case study deals with the PV policy, its impact on the installed PV capacity, the reaction of PV companies and investors, as well as subsequent feed-back loops to policy making. The case studies are structured according to the different phases of the past and future market development based on the diffusion theory framework. In concluding, each case study presents the country-specific factors that have been conducive to the diffusion of PV as well as those having slowed down the process. For this evaluation, a return-risk framework is applied:

Return factors:

a) *Level of tariff:* How high is the financial support?

b) *Duration of tariff:* For how many years is the support guaranteed?

c) *Solar resource:* How abundant is the solar radiation?

Risk factors:

a) *PV policy stability:* Do the policy and financing schemes provide a stable planning horizon? Have there been major, unexpected changes in the past?

b) *Cap:* Is there a cap limiting the amount of PV electricity to be supported under the feed-in tariff, and if yes, how "tight" is this cap (e.g., in terms of years until it will be reached)?

c) *Administrative process:* How many permissions are required? How many authorities are involved? How long does the administrative process take?

The first three factors are categorized as return factors because they describe those elements that positively influence the return on an investment in a PV project. The latter three factors, in turn, describe typical elements that represent policy risks for investors, which may have a negative influence on (expected) return on investment. As is well documented in the literature, unexpected policy changes are an important risk that investors are reluctant to take. A cap may appear as a binary risk at first sight, since one might consider the probability of realizing a return to be zero after the cap has been reached. However, long before the cap is actually reached, it creates uncertainty in the market because investors may not be sure whether their project will be realized before the cap will come into effect. Also often the conditions after the cap has been reached are not specified, and investors may assume that policy-makers will eventually come up with new rules for support of PV. The administrative process constitutes another risk factor. The more permissions are needed and the more authorities are involved, the higher the risk for project delays, or even failures. The stagnation of a project brings along that the internal rate of return of the investment gets worse as money has been spent without producing energy.

2.3 Case study 1: PV market and policy development in Germany

2.3.1 Introduction: 1990–1998

Feed-in tariffs in Germany were officially introduced on January 1st, 1991 when the Electricity Feed-in Law came into force. This law, for the first time ever, put an obligation on grid system operators to purchase electricity generated from RES-E, and to pay a preferential tariff for it (BMU, 2007a). The tariff for PV was equal to that of wind and so, there was not a strong financial incentive to PV investors (Table 2.1).

In addition, there were different initiatives on national ("1000 roofs program", "Cyrus installations" by Greenpeace (Neuner, 2000), regional (e.g., in some states utilities subsidized PV plants (Jacobsson and Lauber, 2006a)) and municipal level (e.g., Aachen model). Although the increase of the PV market was quite limited, these initiatives had two significant effects. First, they led several new, often small firms to enter into and enlarge the PV industry. Second, the large number of cities with local feed-in tariffs and a proliferation of green pricing schemes revealed a wide public interest in increasing the rate of diffusion, and thus legitimized further PV support through public policy.

2.3.2 Early growth: 1998–2003

By January 1999, the "100,000 roofs program" started, providing subsidies in the form of low-interest loans to investors. The Electricity Feed-in Law expired at the end of the 1990s and the new legislation – Renewable Energy Sources Act (EEG) – came into force on April 1st, 2000. In contrast to the Electricity Feed-In Law, a clear goal was set for the expansion of renewable energy sources: With the help of the EEG, electricity production from renewable sources is to rise to at least 12.5% of the total consumption by 2010. [3]

The EEG tariff system is based on the shared burden principle. Under this system, the local grid operators can transfer the cost of their EEG payments to the next higher grid level. At the high voltage transmission line level, costs are balanced out across Germany (Wüstenhagen and Bilharz, 2006b). The financial incentive is thus

[3] In 2008, 14.2% of the total electricity consumption was produced by renewable sources (BMU, 2008).

independent of state budgets, which prevents a stop-and-go policy as there are no budget constraints. The feed-in tariff changes were very positive for PV (Table 2.1). To account for technological progress, the tariff was set to decline about 5% every year for new installations. Further, a cap was set at 350 MW.

In combination with the "100,000 roofs program", the new law led to a situation where PV became a profitable investment option. The deployment took off (Figure 2.2), and within less than three years (mid 2003), the 350 MW cap was reached and the low cost loans of the "100,000 roofs program" ran out. Without these loans, the feed-in tariffs proved insufficient; and as a consequence, investment decisions slowed down greatly in the second half of 2003.

At that time, another amendment to the EEG was on its way, but not yet ready to be enforced. To secure continuous growth of the PV industry, the Interim Photovoltaic Act was adopted in December 2003. The act introduced appreciably higher tariffs for PV and saved the PV industry from collapse. Further, the tariffs were differentiated among type and size of the plant (Table 2.1).

Table 2.1: German Feed-in Tariffs for PV from 1991 – 2008 (since 2004, differentiation of the tariff depending on project type and size)

	Plants installed on buildings [kW]			**Building surface Bonus**	**Greenfield plants**	**Tariff durati on (years)**	**Maximum market cap (MW)**
	<30	**30–100**	**> 100**				
Electricity Feed-In Law:							
1991	8.49[1]					20	--
	8.66[1]					20	--
	8.77[4]					20	--
1998	8.77[1]					20	--
Renewable Energy Sources Act (EEG):							
2000, 2001	50.6					20	350
2002	48.1					20	1000
2003	45.7					20	--
EEG Amendment:							
2004	57.40	54.60	54.00	5	45.70	20	--
2005	54.53	51.87	51.30	5	43.42	20	--
2006	51.80	49.28	48.74	5	40.60	20	--
2007	49.21	46.82	46.30	5	37.96	20	--
2008	46.75	44.48	43.99	5	35.49	20	

[4] Before 2000, the feed-in tariff for solar was equal to that of wind.

2.3.3 Take-off: 2004–2008ff.

The Interim Photovoltaic Act was assumed in the EEG amendment in 2004. Since then, the PV growth has accelerated significantly (BMU, 2007a). Even though the contribution of PV to overall electricity consumption in 2008 reached a mere 0.5% (BMU, 2008), PV installations became a widely visible phenomenon on German rooftops. Due to this strong growth, Germany became the world's most important market for PV systems with 1100 MW (Figure 2.2), followed by Spain with 341 MW, Japan with 210 MW and the US with 205 MW (Jäger-Waldau, 2009). The cumulatitve installed PV system capacity in Europe amounts to 4.7 GW in 2007 (European Renewable Energy Centres Agency, 2008).

Following the 2008 EEG amendment, the annual reduction in feed-in tariffs for new installations increases from 5% to 8–10% from 2009 onwards (BMU, 2008).

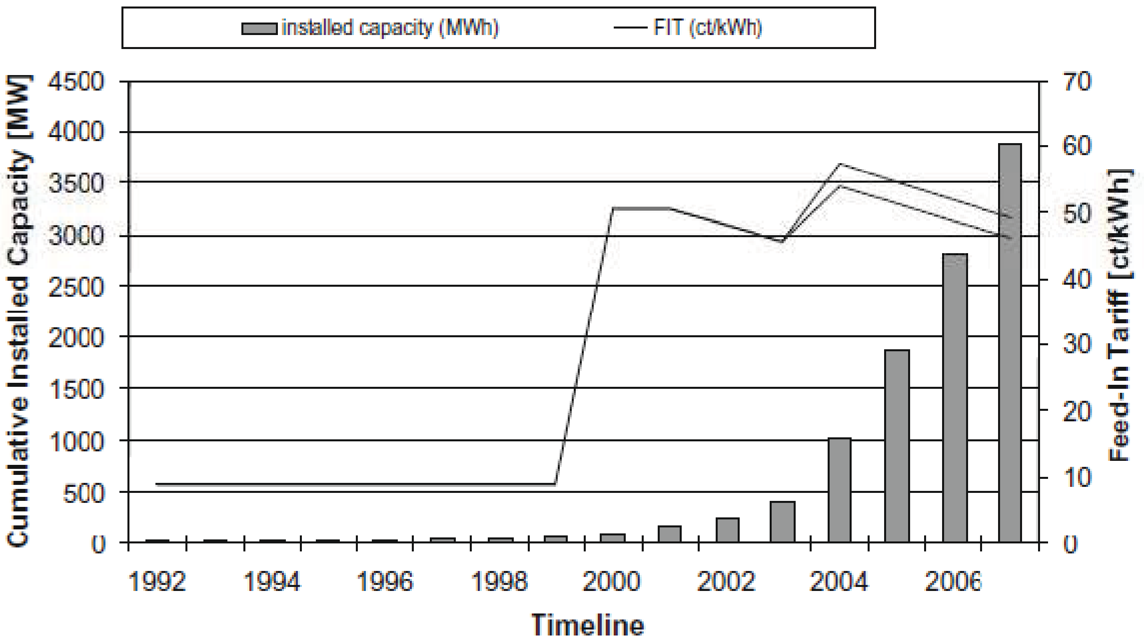

Figure 2.2: Accumulated capacity of PV in Germany (1990–2007) (Data source: BMU (2007b); EEG)

2.3.4 Maturity

The promotion of individual renewable energy technologies will be adapted to current requirements in order to give further impetus for innovation and cost reduction. In amending the EEG, policy-makers had to strike a balance between the fact that the PV industry is still in the development phase and the objective to provide incentives for further cost reduction. PV manufacturers are expected to achieve a significant share of their sales from exports only once measures and instruments currently implemented in other countries will have become effective (by around 2010). Therefore, a sufficient home base in the German market remains of essential importance.

All currently supported plants will continue to benefit from EEG support at least until 2020, as the feed-in tariff is guaranteed for 20 years. Only afterwards, support for the first plants built under the EEG will be phased out. Those plants will continue to provide electricity until the end of their technical lifetime. In 2021, the feed-in tariff for PV will reach 21 ct/kWh[5]; a price that is currently paid by many German consumers. According to projections of the Federal Ministry of the Environment, the national economy will start earning a positive return on its PV investment in 2026 (Nitsch, 2007).

2.3.5 Case study conclusions

The EEG has caused a very positive development in the German PV industry that led to a nine fold increase of the installed capacities between 2003 and the end of 2007 (BMU, 2008). Within just a few years, a highly dynamic industry covering the entire value chain has come into being (BMU, 2007a). Numerous medium-sized enterprises across the whole country are involved in producing power from renewable sources, which reflects the decentralized nature of RES-E generation.

Return factors:

a) Level of tariff: The EEG tariff system, based on the shared burden principle, proved very effective. In the introduction and the early growth phase, the feed-in tariff alone would have been too low to provide an incentive to PV. The combination with low-interest loans and subsidies was important at that time. These financial incentive schemes were essential because they allowed small firms, farmers, and even individuals to invest in PV development. However, they would not have directly produced Germany's success with PV development in and of themselves.

In order to ensure a sufficient return on investments, the level of support needs to be higher than the marginal costs of generation. If this is not the case, the PV growth decreases immediately: At the time the "100,000 roofs program" was scheduled to be stopped in 2003, the domestic PV industry anticipated a strong decrease in demand. The Interim Photovoltaic Act introduced a higher feed-in tariff to prevent the

[5] This calculation is based on the supposition that the annual reduction is maintained at 5% over the coming years. As described above, this will most likely not be the case.

otherwise inevitable layoffs or even the destruction of a whole industry (Jacob, Beise et al., 2005).

b) Duration of tariff: The feed-in tariff is guaranteed for 20 years.

c) Solar radiation: In Germany, the solar radiation amounts to 1000 ± 150 kWh/m^2 p.a. on average. The specific energy yield of PV plants ranges from 750 to 950 kWh/kW$_p$ on average (Weiss, Orthen et al., 2006).

Risk factors:

a) *PV policy stability:* The key strength of the German EEG is the long-term security that it provides to investors. There were no abrupt negative changes in the past, and at critical points in the policy development process, the legislators took fast and decisive action to alleviate potential problems, as in the case of the 2004 EEG amendment. Since PV now enjoys bipartisan support from both conservatives and social democrats, it seems likely that future policy changes will continue on the general path that has been followed so far.

b) Cap: Since 2004, there is no limitation to PV market support.

c) Administrative process: In Germany, there were no major administrative delays and the grid connection is clearly regulated. Except for greenfield plants, no permissions are needed for installing a PV plant.

2.4 Case study 2: PV market and policy development in Spain

2.4.1 Introduction: 1997–2004

The first legislation regulating the participation of renewable energies in the power supply of Spain was the Law of the Electricity Sector in 1997 (Law 54/97). It liberalized, at least partially, the Spanish electricity market in November 1997 implementing the European Directive 96/92/EC on the liberalization of electricity markets.

The Royal Decree 2818 (RD 2818/1998) guarantees purchase for RES-E and fixes the amounts of RES-E support for 1999 (Table 2.2). Producers can choose between the market price plus a premium or a fixed price. At that moment, only very small installations (up to 5 kW) were sufficiently supported.

2.4.2 Early growth: 2004–2006

In 2004, the Royal Decree 436 (RD 436/2004) brought relevant changes with respect to the previous regulation (RD 2818/1998) and gave a decisive boost to the Spanish PV market (Figure 2.3). This Decree tied the feed-in tariff to the reference electricity fee (REF). The updating of the level of tariff is thus automatically established and no longer depends on an annual government decision, which reduces the risks for investors. The national promotion plan defined a clear PV target: 135 MW total installed capacity until 2010.

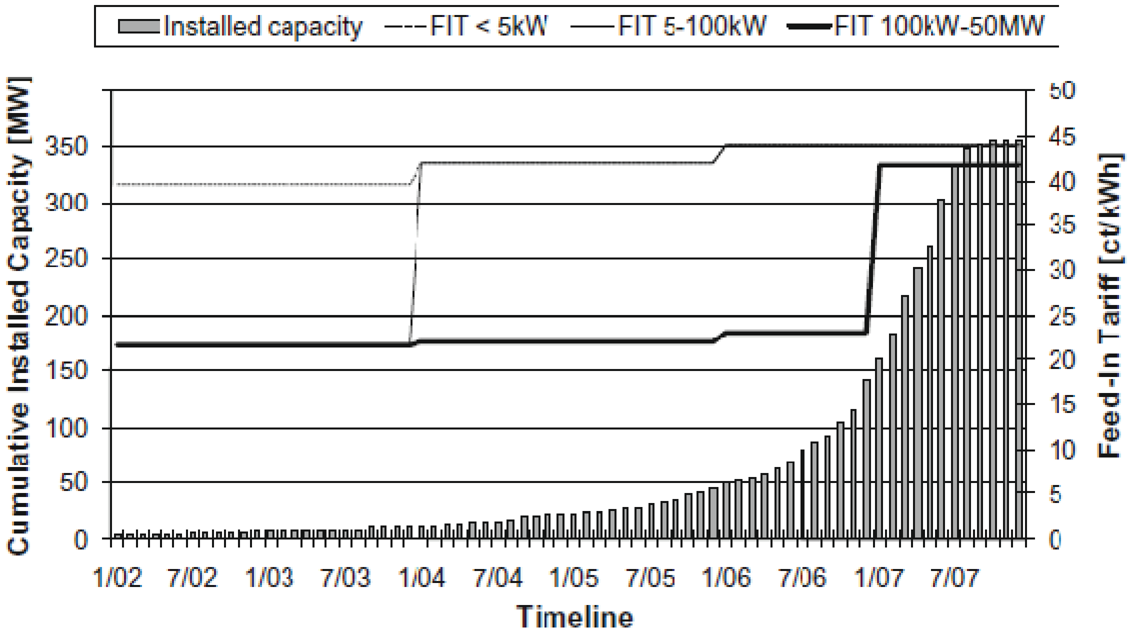

Figure 2.3: Installed PV capacity (MW) and yearly capacity increase (MW) in Spain from 2000–2007 (Data source: Porta (2008))

The RD 434/2004 brought a higher tariff for installations up to a capacity of 100 kW, for bigger installations the tariff was only about half as high (Table 2.2). Such being the case, bigger installations are divided into blocks of 100 kW and subsequently maximal unit capacity mostly is 100 kW. The tariff is guaranteed during the lifetime of installations, with a reduction after 25 years. Moreover, other provisions try to reduce the administrative lead time (by encouraging the coordination between different administrative levels) and to facilitate the access of RES-E to the grid.

Since RD 436/2004 came into effect, the feed-in tariff was the key support instrument. In 2004 and 2005, additional support could be obtained by means of a national funding scheme which combined soft loans with direct subsidies established by IDAE (Institute for Diversification and Saving of Energy) (Weiss, Orthen et al., 2006). In addition, some regions and municipalities offered grants, although most have been cut out following the amendment of the feed-in tariff system to avoid over-subsidizing of the market. In 2006, the national funding program was cancelled and no grants were offered anymore.

The Spanish feed-in tariff, which is not characterized by an annual reduction as in Germany, provides excellent conditions for PV plants. Since the introduction of RD 436/2004, many Spanish and foreign investors have been attracted by the high rates of return (10%) (Sieber, 2007). Also the Spanish banks have discovered PV and are ready to provide loans (Gellings, 2006a).

Despite high prospects, the installed capacity increased only slowly until mid 2006 (Figure 2.3). One of the main reasons for this development is that the rush of applications challenged the administrative procedures; in particular it overwhelmed some local authorities. Another main reason was the speculation problem; because of the high rate of return, many applications were made based on incomplete project planning. Further reasons were ambiguities on the part of the approving authorities, the problems of electricity companies providing grid access and a lack of expertise of the citizens (Gellings, 2006b).

In June 2006, the Minister of Industry suspended the feed-in tariff from the REF actualization of 2006; hence, the tariffs were still tied to the REF of 2005. This very sudden change in the legislation caused a great uncertainty in the whole RES-E sector (Porta, 2008). The hesitance of the PV sector is reflected in a decrease of installed capacity in August and September 2006 (Figure 2.3). The database of the Spanish Industry Department, in which all PV producer and applicants need to register, shows that even some major projects have been stopped (Gellings, 2006b).

In November 2006, the new Minister of Industry presented his draft for a new feed-in law, which was especially advantageous for operators of big power plants (Table 2.2). Hence, for operators of big plants, the previously common procedure to split their application up into 100 kW-blocks is no longer necessary. This reduces technical and administrative expenditures. This course of events illustrates how rapidly things can change with a change of the responsible minister of action.

Table 2.2: Spanish feed-in tariffs for PV from 1998 – September 2008

		RD[6] 2818/1998	RD[5] 436/2004	RD[5] 661/2007
Level of tariff (ct/kWh)	≤ 5 kW	Premium: 36 Incentive: 39.6	575% of REF[7]: 2005: 42 2006: 44	44.04
	5-100 kW	Premium:18 Incentive: 21.6		
	100 kW - 50MW	-	300% of REF[6]: 2005: 21.99 2006: 23	41.75
	> 10 GW	-	-	22.93 (probably just of theoretical interest)
Tariff duration (years)		None	Lifetime of the plant, reduction of the tariff after 25 years (460% resp. 240%)	Lifetime of the plant, reduction of 20% after 25 years
Maximum market cap (MW)		50 MW	150 MW	371 MW

2.4.3 Take-off: 2008ff.

Since the announcement of the new legislation (RD 661/2007) in December 2006, the installation capacity has grown exponentially (Figure 2.3). In May 2007, the RD 661/2007 finally became effective. The fundamental weakness of the new legislation is a promotion cap at 371 MW. As soon as 85% of the cap is achieved, this tariff is valid for one more year (waiting period). So, already by the end of September 2007, only a few months after the new RD came into effect, 85% of the cap was reached. The conditions for the time after the waiting period needed to be fixed in a new law.

Another important change of the new Royal Decree is that investors need to post a deposit of 500 € for greenfield installations (the majority of the Spanish PV plants). This regulation should prevent the speculative acquisition of grid access rights. These changes are the result of the adaptation to the economic situation (Rutschmann, 2007b); the Spanish government aims to reduce the cumulated debt, which resulted from the general subsidization of electricity prices. Formerly, the Spanish feed-in tariff is based on the shared burden principle, thus divided among the consumers. The retail price for electricity was for a long time fixed by the Spanish government and the market price of electricity was negotiated at the power exchange. So it could happen that the electricity was sold to the population to a cheaper price than it was bought (a situation that is very similar to the one leading to the major electricity market crisis in

[6] RD: Royal Decree
[7] REF: Reference Electricity Fee

California in 2001). By fixing the electricity prices, the government meets the costs of the feed-in tariff practically with the public purse.

As from September 26, 2008, the new RD 1578/2008 brings a significantly lower tariff (32–34 ct/kWh). Further, it fixes a yearly promotion cap of 500 MW for the next three years (Rutschmann, 2008).

2.4.4 Case study conclusions

Return Factors:

a) Level of tariff: The introduction of a sufficiently high feed-in tariff gave the Spanish PV industry the decisive boost. In comparison to Germany, the Spanish tariffs are indeed a few cents lower, but the Spanish tariff it is paid over lifetime of the plant (with a reduction after 25 years) and the solar yield is 1.5 times as high as in Germany.

b) Duration of tariff: The feed-in tariff is guaranteed over the lifetime of a plant, with a 20% tariff reduction after 25 years.

c) Solar radiation: In Spain, the solar radiation amounts to 1500 ± 300 kWh/m^2 p.a. on average. The specific energy yield of PV plants ranges from 1000 kWh/kW$_p$ in the North to 1500 kWh/kW$_p$ in the South on average, for systems without solar tracking (Weiss, Orthen et al., 2006).

Risk factors:

a) PV policy stability: Compared to Germany, the changes in the Spanish policy have been more abrupt. In June 2006, the suspension of the REF actualization for feed-in tariffs led to a regulatory uncertainty that made banks and project developers hesitate to make further investments.

b) Cap: The achievement of the 85% of the promotion cap of 371 MW in September 2007 led to an abrupt standstill in the PV deployment. Because of the legal insecurity regarding the support situation after the waiting period, investors, project developers and banks were no longer willing to finance projects.

c) Administrative process: The application for grants (especially at regional level) was very bureaucratic. The simplification of administrative procedure by RD 436/2004 was a basic prerequisite for the development of the PV sector. In the early growth phase, the application rush resulted in some administrative delays, and problems of electricity companies with grid connection also prolonged the whole procedure. In 2007, four authorities are involved in the authorization process, which still takes about 6 or 18 months (for a connection to low or high voltage). Another two months are needed for grid connection.

2.5 Case study 3: PV market and policy development in Greece

2.5.1 Introduction phase: 1994–2008

Although Greece was the first country in Europe to install wind parks in 1982 and one of the first to install a PV park of 100 kW in 1983, both on Kythnos island (Strauss, Kleinkauf et al., 2001), the installed RES-E capacity did not increase as quickly as expected.

In 1994, Greece gave the private sector the opportunity to invest in RES-E by introducing the legal framework 2244/94. According to this legislation, each independent producer would receive a feed-in tariff harmonized with the tariffs of the Public Power Corporation. This law helped in significant increase of the wind power capacity in Greece, especially on Crete (Tsikalakis, Hatziargyriou et al., 2003) and the remuneration price of 70.9€/MWh (on 2000) gradually increasing was also beneficial for the operators of island power systems. As the law did not make any distinction between the different RES-E, prices were relatively low for PV and very few were installed with major installation the one described by (Kymakis, Kalykakis et al., 2009). Moreover, planning and authorization procedures were very time consuming. At least 17 permissions were required (among others, installation, building, civil work and operation license, grid connection, feed-in contract) and more than 40 authorities at local, regional and national level had to be contacted. The administrative procedure took about 6–12 months for smaller and at least 2.5 years for larger projects (Urbschat, 2006).

In June 2006, Greece introduced the RES-E law (3468/2006) which aims at promoting RES-E to meet EC Directive targets of 20.1% RES-E of electricity consumption by 2010. The funding source is a surcharge on the electricity price. According to the new feed-in system, the tariff for PV installations amounts to 40–50 ct/kWh (Table 2.3). The guaranteed duration is 10 years, with an option for an additional 10 years for which only a statement of the operator is necessary. Further, the Greek tariff is not subject to an annual reduction, but increases with inflation and rising electricity prices.

Table 2.3: Greek feed-in tariff scheme according to the RES-E Law 3468/2006

	Mainland (ct/kWh)	Non interconnected islands (ct/kWh)
PV<100kW	45	50
PV>100kW	40	45
Other solar energy systems <5 MW	25	27
Other solar energy systems >5 MW	23	25

Besides these attractive figures, the Investment and Development Law 3299/2004 (incl. modifications 2006/07) offers investment subsidies of 30–55% to commercial operators. This law provides investment incentives to promote the competitiveness of the Greek economy, which includes the promotion of RES-E. Another source for investment subsidies for commercial operators is the Operational Program (OP), funded by Community Structural Funds. If private operators want to get funding either from the Development Law or from the OP they have to apply as a company. Otherwise, private operators only have the possibility of a tax reduction up to 700 € per installation.

The introduction of the new feed-in tariff scheme led to the development of financing programs for PV by numerous Greek banks, among others the Piraeus Bank. The attractive financing framework for investors on PV includes: low-interest loans, leasing contracts of 3–5 years and an insurance program against malicious actions or against physical disasters.

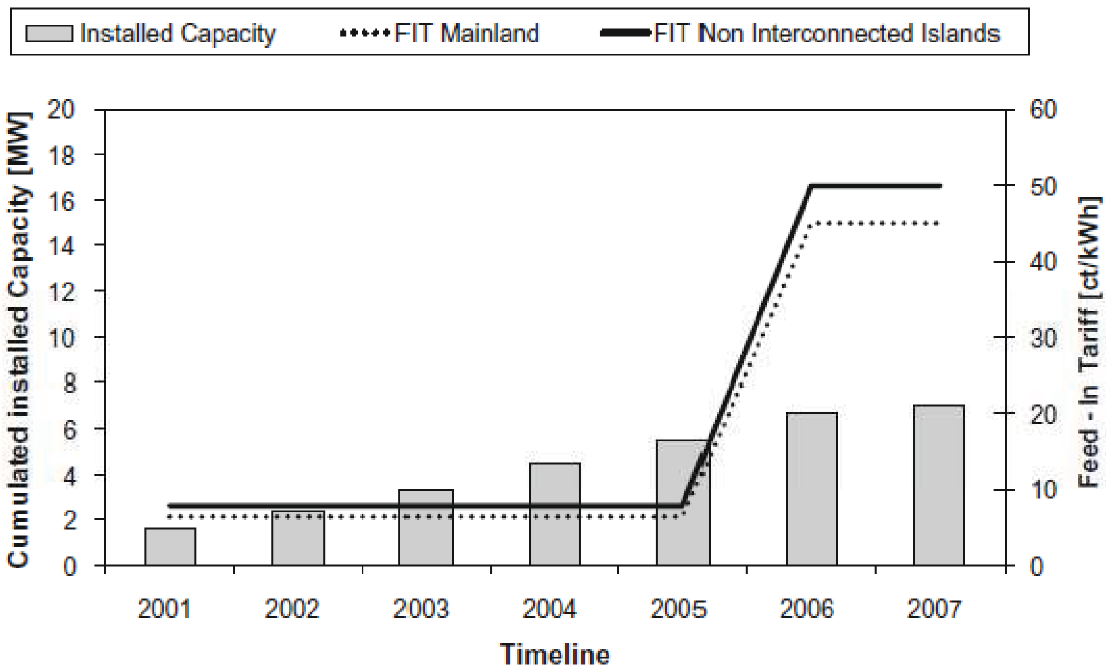

Figure 2.4: Evolution of installed capacity (MW) of PV from 2001 – 2007 in Greece. (Data source: HTSO (2009))

Besides the mentioned changes making the installation of PV systems more financially viable, one of the greatest achievements is that the application procedures for small to medium-sized installations (up to 150 kW) have been significantly simplified and accelerated. As of now, small installations (<20 kW) do not need licenses any more. They need to register and to pass through the procedures for connection to the grid. Operators of installations from 20 to 150 kW will, in the future, be exempt from having to apply for numerous licenses (e.g., installation and operation licenses), they only need to go through a series of environmental impact assessments.

Due to the much higher feed-in tariff schemes compared to the past, the capacity applied for authorizations was 4–5 times higher compared to the initial goals of the program set by the government. In spring 2007, Regulatory Authority for Energy (RAE) enacted a moratorium on new admissions because of a significant application backlog. However, only very few capacities have been installed up to now (Figure 2.4) (HTSO, 2009).

A main barrier to the increase of PV capacity in Greece is the complexity of the legal framework and particularly the licensing procedure. On the one hand, many investors applied for PV authorizations without being very well prepared. This caused delays in the examination and sometimes a refusal of the projects. On the other hand, the number of applications was much higher than expected. Some of the authorities may not have been well prepared or did not have enough employees for this extreme number of applications, leading to some delays in the implementation of the program. A major problem regarding administrative issues was that the rest of legislation for PV installations, such as environmental, authorizations for buildings and so on remained intact. Thus, the employees, especially in local authorities, have not a clear view of the procedure they should follow for providing quickly the necessary authorizations. Moreover, they lack co-ordination by the central ministries. Furthermore, not all administration guidelines are elaborated (Psomas, 2007). This situation may be frustrating for the small investors and few of them have already started selling the granted authorizations to larger companies to avoid all this bureaucracy.

A second, but lower barrier is the access and connection to the grid. The delay in the reaction of the utility for PV access to the grid (as well as for any other RES-E) is about 4–6 months. RAE in co-operation with this distribution Network operator (DNO) and the Hellenic Transmission System Operator (HTSO) has issued a technical advice on the rules of interconnection of PV. This advice has caused some temporary delays but has helped in ensuring avoidance of major disturbances in the electrical grids caused by PV.

2.5.2 Early growth: 2009ff.

As soon as administrative processes are initiated and made clearer, Greece can be expected to attract the interest of international companies. First, the financial incentive scheme is especially attractive for commercial operators; second, companies will become acquainted with the application procedures; and third, the case of Greece enables the building of bridges to future markets in other parts of South-Eastern Europe.

2.5.3 Take-off

It is too early to tell when the Greek PV market will reach the take-off phase.

2.5.4 Case study conclusions

Apart from the high solar radiation, there are two additional main reasons for the very high PV potential in Greece. This country's territory includes a vast number of islands not connected to the national electricity grid. Up to now, the electricity needs on these islands have been mostly met by diesel or heavy oil generation units, thus resulting in high operation costs and environmental pollution. The second reason is that the significant tourism activity during summer offers a good correlation between energy demand and PV power generation. Despite this advantageous point of departure, the Greek PV market has not developed to significant levels yet.

Return factors:

a) Level of tariff: In Greece, the level of support is very high. The feed-in tariffs alone would already result in a profitable support level, comparable to the Spanish situation. It is higher than in Spain but in return guaranteed only for 20 years. Additional support is given by the national and EU budget by grants or taxes. According to experts, the grants will be guaranteed only during the starting period.

b) Duration of tariff: The feed-in tariff is guaranteed only for 10 years, with an optional extension to another 10 years that is relatively straightforward

c) Solar radiation: The solar radiation is, on average, very similar to the Spanish radiation. In Greece, it amounts to 1500 ± 200 kWh/m^2 p.a. on average. The specific energy yield of PV plants ranges from 1300 kWh/kW$_p$ in the North to 1500 kWh/kW$_p$ in the South on average, for systems without solar tracking (Weiss, Orthen et al., 2006).

Risk factors:

a) PV policy stability: The fact that the authorities have been overrun by the applications led to a temporary admission break. As the Greek public PV promotion is very young, the situation is in general seen as not very stable.

b) Cap: There is no cap limiting the promoted capacity.

c) Administrative process: The administrative process is very complicated and time consuming. For operators of an installation of a capacity from 20 to 150 kW who "only" need environmental permits, the procedure still requires about one year. For bigger installations, the installation and operating licenses take about 9 months, the application for subsidy another 4–6 months. Plants below 20 kW only need registration, but in 2007, the administration did not at all commence operations (Hirshman and Siemer, 2007). These long procedures are, among others, caused by the lack of coordination between the ministries involved in the procedures for the licenses.

2.6 Conclusions and Outlook

The analysis of the three countries showed that the different deployment levels of PV can to a large extent be traced back to the return and risk criteria defined above (Table 2.4). Return-related factors show favorable conditions in Germany and very favorable conditions (++) in Spain and Greece. The nominal level of the feed-in tariffs for small and medium-sized installations is relatively similar across the three countries investigated. The financial support conditions of the three analyzed countries are favorable (+) to very favorable (++). They are very favorable in Greece because companies can apply for further support through grants and taxes on top of the feed-in tariff (++). The fact that the levels of solar radiation in Spain and Greece are approximately 1.5 times higher than in Germany provides very attractive conditions for investors in those two markets (++). One important mediating factor is the duration of the feed-in tariff. While the feed-in tariff is guaranteed for 20 years in Germany (+) and for 10 + 10 years in Greece (+), it applies over the full lifetime of a plant in Spain (which may be 30 years or more), with only a 20 % reduction after year 25 (++). Looking at the return side of the equation, one would therefore expect a particularly high level of market diffusion in both Spain and Greece because of the very favorable return conditions (++), whereas return conditions are somewhat less favorable in Germany (+).

In contrast to this expectation, the level of PV diffusion appears to be largely unrelated to factors determining the level of return. Instead, there seems to be a strong correlation between policy risk and market diffusion. As a result, the implementation of a feed-in tariff is likely to increase a country's PV capacity, but how effectively this objective will be reached is mediated by policy risk factors. Beyond a certain point, the level of market diffusion will not increase proportionally to the level of achievable returns, but will be very sensitive to investment barriers such as administrative hurdles, grid access and the risk of policy changes.

Table 2.4: The influence of return and risk factors on the level of diffusion (2008)

	Germany	Spain	Greece
Return	+	++	++
- Level of tariff	+	+	++
- Duration of tariff	+	++	+
- Solar radiation	O	++	++
Risk	++	(+) – –	(– –) –
- PV policy stability	++	(+) – –	O
- Cap	++	– –	++
- Administrative process	++	+	(– –) –
Level of diffusion	**High**	**Medium**	**Low**

++ = very favorable; + = favorable; O = medium; – = unfavorable; – – = very unfavorable; ( ) situation in 2006

Spain and Greece both face important challenges in these regards. The case study of Spain illustrated how important policy stability is to investors. Sudden and unannounced changes in the legislative framework (as in June 2006) or uncertainty about the future regulatory framework (as in the period after September 2008) irritate investors, plant developers and banks (– –). The analysis of the Spanish PV policy also highlighted the negative influence of a cap, which leads to a boom-bust cycle in PV market development (– –). This can be avoided if the transition to a new regulatory framework is managed well in advance, as in Germany in 2003/04 (++).

The case study of Greece showed the crucial role of administrative processes for PV market deployment. It is important to streamline the various aspects of the licensing procedure (including building permits, environmental assessments, grants and grid access). Small and medium-sized installations should be subject to simplified procedures, and the number of authorities involved should be kept small. Capacity building for local authorities and provision of clear roadmap for issuing authorizations is important to ensure they are up to date with regard to current regulations.

As with any piece of research, this study is subject to some limitations that provide starting points for further research. It would be of high value to follow-up the conclusions of the qualitative research study with a quantitative study. Such a study could identify the most relevant risk factors and quantify their importance in regard to return factors, e.g., calculate how much the return may be lower if the administrative process duration is shorter (without a loss of attractiveness for investors). This would make it possible to give specific recommendations about how policy-makers should prioritize the different policy factors.

While this analysis has provided strong evidence that risk-return considerations have indeed played an important role in determining the level of PV market deployment, one additional factor that was only capture to a limited extent is the difference in timing across the three countries investigated. The feed-in tariff in Germany was introduced in 2000, with a substantial increase for PV since 2004. In Spain, the feed-in tariff was introduced in 1998 for small installations (<5 kW) and in 2004 for installations up to 100 kW. In Greece, a dedicated and differentiated feed-in tariff for PV was only introduced in 2006. Hence, some of the variation in the level of market diffusion may be a function of the time lag between countries. This limitation can be overcome by further comparative research once more markets have reached a similar level of maturity.

Another interesting avenue for further research is to investigate the influence of international policy learning. Much of the early German policy development took place in the absence of any international benchmark for successful renewable energy deployment policies. Countries introducing such policies more recently can draw on this example, potentially leading to an accelerated policy development. However, this may also lead to incomplete policy transfer, as it might be difficult to implement one country’s specific policies in another country. This study gives some early evidence that some of the Mediterranean countries have underestimated the role of policy risk as a factor determining market diffusion at least as much as the level of feed-in tariffs.

Finally, this country-level analysis is limited to an aggregated, ex post assessment of what has influenced the investment decisions of PV market players. It may be worthwhile to complement this with a firm-level analysis, surveying internationally operating PV companies and deepening the understanding of how they assess the attractiveness of PV policies.

Investigating the effectiveness of PV policies in Germany, Spain and Greece, this paper has demonstrated that the level of PV diffusion appears to be – above some minimum threshold – largely unrelated to factors determining the level of return, but there is a strong correlation between policy risk and market diffusion. As a consequence, installed PV capacity does not increase proportionally to the level of return but is very sensitive to the consistency and stability of the support. Therefore a feed-in tariff is an important condition for growing installed PV capacity, but it only results in effective deployment if policy risks are carefully managed.

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2.8 Supporting Material

2.8.1 Questionnaires DISTRES Survey

WP 2: Market survey and economic analysis: Task 2.1 Solar thermal and PV financing schemes

Form A

A1. Which of the following financing schemes are currently being implemented in your country for solar power promotion?

- ☐ Grant/Investment incentives
- ☐ Tax incentives
- ☐ Low interest credit
- ☐ Shareholder programs
- ☐ Leasing/ Contracting
- ☐ Tendering system
- ☐ Feed-in tariffs
- ☐ Green power marketing

Comments:____

____

A2. Which of the following financing schemes are currently being considered or planned in your country for solar power promotion?

- ☐ Grant/Investment incentives
- ☐ Tax incentives
- ☐ Low interest credit
- ☐ Shareholder programmes
- ☐ Leasing/ Contracting
- ☐ Tendering system
- ☐ Feed-in tariffs
- ☐ Green power marketing

Comments: ____

____

____

A3. For the financing schemes used in your country, please indicate the level of effectiveness[1] on a scale 1 (worst) to 5 (best).

- ☐ Grant/Investment incentives: 1 2 3 4 5
- ☐ Tax incentives: 1 2 3 4 5
- ☐ Low interest credit: 1 2 3 4 5
- ☐ Shareholder programmes: 1 2 3 4 5
- ☐ Leasing/ Contracting: 1 2 3 4 5
- ☐ Tendering system: 1 2 3 4 5
- ☐ Feed-in tariffs: 1 2 3 4 5
- ☐ Green power marketing: 1 2 3 4 5

Comments: ____

____

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____

[1] Effectiveness: Degree of achieving the programme's/policy's objective (e.g. in terms of capacity installed)

A4. For the financing schemes used in your country, please indicate the level of efficiency[2] on a scale 1 (worst) to 5 (best).

☐ Grant/Investment incentives: 1 2 3 4 5
☐ Leasing/ Contracting: 1 2 3 4 5
☐ Tax incentives: 1 2 3 4 5
☐ Tendering system: 1 2 3 4 5
☐ Low interest credit: 1 2 3 4 5
☐ Feed-in tariffs: 1 2 3 4 5
☐ Shareholder programmes: 1 2 3 4 5
☐ Green power marketing: 1 2 3 4 5

Comments: ____

____

____

____

____

A5. Which of the following financial schemes do you prefer to be designated to best promote solar power in your country?

☐ Grant/Investment incentives
☐ Leasing/ Contracting
☐ Tax incentives
☐ Tendering system
☐ Low interest credit
☐ Feed-in tariffs
☐ Shareholder programmes
☐ Green power marketing

Why? ____

____

____

Please fill in form B for each promotion programme actually in operation and send or fax the forms to the IWOE until October 15:

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Fax: +41 (0)71 224 27 22

[2] efficiency: Ratio of output (e.g. capacity installed) to input (e.g. amount of subsidies)

Form B

Please fill this form for each promotion programme actually in operation

B1. Name of the program ______________________________

B2. Brief description of the financing scheme
____
____
____
____
____
____
____

B3. Promoter

Capital provider:

- ☐ National Government
- ☐ Regional Government: ______________________
- ☐ Municipality: ______________________
- ☐ European Commission
- ☐ other international body: ______________________
- ☐ Bank: ______________________
- ☐ Power company: ______________________
- ☐ Other: ______________________

Payment body:

- ☐ National Government
- ☐ Regional Government: ______________
- ☐ Municipality: ____________________
- ☐ Bank: ______________________
- ☐ Power company: _______________
- ☐ Other: ______________________

Dept repayment collector:

- ☐ National Government
- ☐ Regional Government: ______________
- ☐ Municipality: ____________________
- ☐ Bank: ______________________
- ☐ Power company: _______________
- ☐ Other: ______________________
- ☐ does not apply

B4. Target group (Beneficiary)

- ☐ Private Person
- ☐ SMEs
- ☐ Large enterprise
- ☐ Trade
- ☐ Farming
- ☐ Forestry
- ☐ Municipality
- ☐ Other: ____________ (Please specify)

B5. Legislation ________________

B6. Funding source

- ☐ Tax
- ☐ Surcharge on electricity price
- ☐ Bank
- ☐ Other: ____________ (Please specify)

B7. Geographical scope

- ☐ EU
- ☐ National
- ☐ Regional
- ☐ Communal

B8. Installation conditions (Installation type, capacity, etc.)

____

____

____

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____

____

B9. Financing scheme

Investment focused	☐ Price-driven	☐ Grant/Investment incentives
		☐ Tax incentives
		☐ Low interest credit
		☐ Shareholder programmes
		☐ Leasing/ Contracting
	☐ Quantity-driven	☐ Tendering system
Generation based	☐ Price-driven	☐ Feed-in tariffs
		covers the costs ☐ totally
		☐ partly
		☐ Green power marketing
	☐ Quantity-driven	☐ Tendering system
		☐ Quota obligation (RPS) based on TGCs

B10. If investment focused

☐ Repayable

☐ Non-repayable

B11. Financing

- Investment focused:

Level of the tariff: ______ €/kWp

- Generation based:

- Level of the tariff: _______ ct/kWh

  ☐ decreasing tariff: _____________

Guaranteed duration of the tariff: ____________

B12. Financing details

If there is a website with additional information in English or French, please indicate the address:

____

- **Background**

____

____

____

____

- **Financing scheme design/ management**

____

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- **Objective of the financing scheme**

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- **Development of the financial incentives**

Year	Specific financial incentives [€]	Number of plants	Installed capacity per year [kW]	Annual production [MWh]	PV Power price [€/kWh]	Number of applications/ PV area applied for
2007						
2006						
2005						
2004						
2003						
2002						
2001						

If there were changes in the financial incentives, for which reasons took they place?

____

____

____

____

- **Historical development of actions and campaigns of the financing scheme** (initial goal, applications (sufficient funds?), new campaign, etc.)

____

____

____

- **Timing**

____

____

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- **Costs of implementing the financing schemes**

____

____

____

____

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____

- **Finances**

____

____

____

B13. Success

- **Quantitative results** (Please indicate year of reference)

Year of reference	2006	__________ (year, please specify)	__________ (year, please specify)
Number of received applications			
Funds applied for			
Funds paid			
PV area applied for			
Portion of systems not implemented			
Implemented area			
Implemented capacity			

- **Replication potential**

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- **Communication**

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B14. Future prospects

- **Monitoring**

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- **Analysis and lessons learned**

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- **Future prospects**

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15. Can this financing scheme be cumulated with other programmes (which?)

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B16. Contact of a person responsible for the financing scheme for further information

Homepage:

Name:

e-mail:

Phone:

B17. Contact of the person who filled in the form

Institution:

Name:

e-mail:

Date:

Please send or fax the forms to the IWOE until October 15:

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3 The Price of Policy Risk – Empirical Insights from Choice Experiments with European Photovoltaic Project Developers[8]

Sonja Lüthi and Rolf Wüstenhagen*

Abstract

Managing the transition to a renewable energy future is an important policy priority in many countries. Solar photovoltaic (PV) technology is expected to make an essential contribution, but due to relatively high cost, its growth to date has been largely driven by public policy, notably feed-in tariffs. Feed-in tariffs have been implemented in various countries, but with widely differing outcomes in terms of installed PV capacity. Previous research indicates that the level of policy risk may be an important driver for differences in renewable energy policy effectiveness. This paper suggests that project developers who make a decision between PV investment opportunities in different countries carefully weigh feed-in tariff-induced returns against a set of policy risks, and choose the country with the most favorable risk-return profile. This model is empirically tested by a stated preference survey among European PV project developers, consisting of 1575 choice decisions by 63 investors. The findings demonstrate that risk matters in PV policy design, and that a "price tag" can be attached to specific policy risks, such as the duration of administrative processes or uncertainty induced by an approaching capacity cap. Governments can build on these empirical results to design policies that will be effective in attracting private PV investment, while at the same time maintaining efficiency by providing an adequate compensation for policy risk.

Keywords: Adaptive conjoint analysis; Choice experiment; Feed-in tariff; Photovoltaic; Policy design.

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[8] Chapter 3 is referred to as study 2 in this doctoral thesis.
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Earlier versions of this article were presented at the GRONEN conference in Nicosia (May 28-29, 2008), the oikos PhD Summer Academy in Kaubad (August 2008), the 32nd IAEE International Conference "Energy, Economy, Environment: The Global View" in San Francisco (June 21-24, 2009), the 10th IAEE European Conference: "Energy, Policies and Technologies for Sustainable Economies" in Wien (September 7-10, 2009) and the Conference on the promotion of Distributed Renewable Energy Sources in the Mediterranean region" in Nicosia (December 11-12, 2009).

3.1 Introduction

In order to address the twin challenges of climate change and energy security, governments around the world are increasingly adopting policies to increase the share of renewable energy. While the overall share of renewable energy in global electric power supply is still low, there is significant growth in some subsectors. For example, 39 % of all newly installed power generation capacity in Europe in 2009 was based on wind energy, and the wind turbine industry has grown by 29 % per annum over the past decade. Solar photovoltaics (PV), while starting from lower levels, has seen even higher growth rates from 2004 to 2008. While the cost of wind energy has reached grid parity in good locations and hence it is sometimes the most competitive source of electricity, the cost of solar PV is still significantly higher than that of conventional electricity sources. Therefore, growth of the PV market has been largely driven by policy incentives.

One of the most widely adopted policy instruments to support PV is the feed-in tariff scheme, first introduced in Germany's renewable energy legislation in 1991. More recently, feed-in tariffs have been enacted in a large number of countries, partly as a result of the apparent effectiveness in increasing renewable energy capacity in Germany. As this policy has spread across countries, however, an important empirical puzzle emerged: seemingly similar policy frameworks have led to significantly different outcomes in different countries. For example, Germany, Spain and Greece all offered feed-in tariffs of approximately 45 ct/kWh for solar electricity generators in 2007, but newly installed capacities in that year ranged from 1.135 MW in Germany to 505 MW in Spain to just 2 MW in Greece (Sarasin, 2009).

An increasing body of research tries to shed light on the reasons behind such differences in energy policy effectiveness. While early contributions in this strand of research have highlighted the importance of sufficiently high support levels and the long-term stability of policy frameworks, more recent work is drawing attention to the importance of policy risk. There seems to be an emerging consensus that an important feature of effective policies is that they succeed in reducing risk for investors. However, empirical evidence to identify the most important risk factors is still limited, and valid results on the relationship between specific attributes of policy risk and investment outcome are difficult to find because there are only a small number of cases where significant levels of new renewable energy capacity have been achieved.

Our research addresses these challenges by moving from an ex post analysis of revealed preferences to an ex ante analysis of stated preferences of key decision-makers in the solar market. We conducted a survey among European PV project developers using choice experiments. This methodology is widely used in marketing research and has recently gained some popularity in the energy and resource economics literature, but, to the best of our knowledge, the current paper is the first to apply this methodology to the analysis of investment choices based on renewable energy policy frameworks. As a result, our research allows the empirical measurement of the "price of policy risk", i.e. project developers' willingness-to-accept (WTA) certain policy risks. This allows policy-makers to make a more conscious trade-off between the level of feed-in tariff offered and the reduction of important policy risks for project developers, ultimately leading to more efficient policy frameworks.

The structure of the paper is as follows. The next section reviews existing literature on renewable energy policy effectiveness and the role of policy risk in renewable energy investment. Section 3.3 describes our experimental design, and the estimation model is specified in section 3.4. Section 3.5 outlines the data and sample; section 3.6 presents and discusses the empirical results. Section 3.7 concludes with implications for policy-makers and suggestions for further research.

3.2 Literature Review

Investigating the efficiency and effectiveness of renewable energy policies has become a popular theme among energy economics researchers. A large number of country-level case studies have been carried out across different geographies, renewable energy technologies and policy instruments (Jacobsson and Lauber, 2006b; Wüstenhagen and Bilharz, 2006a; Breukers and Wolsink, 2007; Lipp, 2007; Toke, Breukers et al., 2008). While some early works pointed to a potentially higher efficiency of trading schemes such as renewable portfolio standards, quota systems and green certificates (Kühn, 1999; Lenz and Pfaffenberger, 1999), feed-in tariffs – especially in the case of Germany – soon built a reputation for being more effective in increasing new renewable energy capacity (Rickerson and Grace, 2007). As more countries introduced renewable energy policy schemes, an additional insight emerged, namely that the answer to the question of which energy policy is most efficient and most effective may actually be that "it depends". For example, as much as trading schemes appear to be an elegant way of minimizing cost to society in economic models (Palmer and Burtraw, 2005), their implementation in real life suffers from limitations including market power and transaction cost (Amundsen and Mortensen, 2001; Jensen and Skytte, 2002; Menanteau, Finon et al., 2003; Verbruggen, 2004; Jacobsson, Bergek et al., 2009;

Verhaegen, Meeus et al., 2009; Bergek and Jacobsson, 2010). Conversely, feed-in tariffs seem to work well in Germany, but are sometimes criticized for their relatively high cost, especially in the case of PV (Frondel, Ritter et al., 2008), which may also be related to the market power of incumbents (Ropenus and Jensen, 2009), and their implementation in other countries showed a striking variety of outcomes (Rowlands, 2005; Campoccia, Dusonchet et al., 2009; Lüthi, 2010). Recent analyses, on the other hand, demonstrate that well-designed feed-in tariffs might actually outperform trading schemes in both efficiency and effectiveness (Ragwitz, Held et al., 2007; Butler and Neuhoff, 2008; OECD/IEA, 2008). One way of summarizing the state of debate is that for many renewable energy policies, the devil is actually in the details (Ringel, 2006), and it is a fine-tuned set of ingredients of a country's policy mix rather than any archetype of a "price-driven" or "quantity-driven" policy instrument that results in efficient and effective deployment of renewables (Menanteau, Finon et al., 2003; Dinica, 2006). Those ingredients that policy-makers must get right beyond the ideal choice of policy type include a series of so-called non-economic barriers to renewable energy implementation (OECD/IEA, 2008), such as planning restrictions (Nadaï, 2007) and connection charges (Butler and Neuhoff, 2008).

A recent stream of research has highlighted the importance of risk in policy design. Variations in policy outcomes can thus be traced back to variations in the level of risk implied by different policies. This has been offered as an explanation for why feed-in tariffs have resulted in higher levels of new renewable energy capacity than green certificate systems (Mitchell, Bauknecht et al., 2006). Lowering risk is a particularly important feature of policy design because of its impact on financing cost for renewable energy projects (Wiser and Pickle, 1998; Langniss, 1999; De Jager and Rathmann, 2008). Policies that effectively reduce (perceived) risk for investors are more likely to result in large-scale deployment of renewable energy. There have been various calls for including an investor or project developer perspective in the analysis of energy policies (e.g., Birol, 2003; Dinica, 2006; Gross, Blyth et al., 2009; Menichetti and Wüstenhagen, 2010), and yet there is relatively little empirical evidence so far about how policies and their risk are actually perceived by investors and project developers (Bürer and Wüstenhagen, 2009; Masini and Menichetti, 2010a). The analysis presented here is an attempt to contribute to this emerging stream of research, and at the same time to address two limitations of previous research that remain largely unaddressed: first, much of the previous research trying to assess the impact of risk on renewable energy policy effectiveness is based on country-level case studies, which inherently limits the analysis to aggregate measures of risk in a given country, rather than leading to specific insights about the importance of individual risk components. Second, the empirical literature has largely relied on ex post analyses of revealed preferences, i.e., realized investments. This may be fine in slow-moving markets where long time series are available, but creates a problem in the dynamic renewable energy market in that it inherently limits analysis to those few countries that already offer some history in deploying renewables, and in that the policy recommendations based on such ex post analyses might systematically come too late. What we suggest is to move towards choice experiments with project developers as a way to get real-time information about how policy risks affect today's investment, and hence tomorrow's installed capacity (Usher, 2008).

3.3 Experimental Design

3.3.1 Method

The objective of this study is to investigate the influence of the most important attributes of solar energy policies on the decision of a PV project developer to invest in a given country, in order to empirically measure their willingness-to-accept specific policy risks. As a result, we aim at providing recommendations for the design of effective PV policies. Investigating the influence of policy attributes on project developers' decisions can be done through either revealed or stated preference approaches. Revealed preference approaches are based on an ex post analysis of actual investment decisions. An important requirement thus is that sufficiently long and detailed time-series data are available. In the case of international solar energy investments, we are addressing a phenomenon that has only emerged in the last 2-3 years, and hence only a limited amount of country-level data would be available for analysis. Stated preference approaches, on the other hand, can overcome some of the challenges of revealed preference methods. By confronting respondents (in this case, project developers) with hypothetical, but realistic, choice situations, decision behavior can be studied in real time, or even before it actually occurs in the field. Consequently, stated preference approaches have become popular in marketing research with regard to understanding consumer preferences for newly developed products (Green and Srinivasan, 1990). One particularly popular method is choice experiments, also referred to as conjoint analysis in the marketing literature. Conjoint analysis was initiated by mathematical psychologists (Luce and Turkey, 1964; Kruskal, 1965; Anderson, 1970) and was introduced in marketing research in the early 1970s (Green and Srinivasan, 1990; Orme, 2007b). Over time, the use of choice experiments and conjoint analysis has spread from its origin in marketing research to a wide array of research communities such as entrepreneurship (Lohrke, Holloway et al., 2010a), environmental economics (Boxall, Adamowicz et al., 1996; Roe, Boyle et al., 1996; Farber and Griner, 2000; Ahn, Jeong et al., 2008; Casey, Kahn et al., 2008; Burkhalter, Känzig et al., 2009; Chattopadhyay, 2009; Glenn, Wattage et al., 2010), transportation economics (Hensher, 1994; Train and Wilson, 2008; Hensher, 2010) and energy efficiency research (Poortinga, Steg et al., 2003; Moxnes, 2004; Banfi, Farsi et al., 2008).

The methodological approach of this study is novel in that it uses choice experiments to investigate PV project developer choices among policy frameworks. Hence, we argue that a project developer's choice among different opportunities to develop international solar energy projects is essentially similar to the decision of a customer to buy a new product. In particular, we assume that these investment decisions comply with the fundamental assumptions underlying conjoint analysis (Lancaster, 1966), namely that project developer will choose from a given choice set the alternative that maximizes their utility, and that this utility can be described as the sum of part-worth utilities of the alternatives' attributes. The utility maximization theory has been successfully applied to the analysis of company preferences or financial product research in other studies. Venditti et al. (2007) for example, evaluated complex financial deals using ACA. Instead of spending many hours evaluating financial deals and presenting the details of those deals to a committee of three individuals, they developed a decision model approach to evaluate deal approval likelihood for structured finance products. The market simulator based on three respondents was found to be highly predictive of whether deals were approved or rejected in the months following the surveys (accuracy of about 80%). The study demonstrated that effective conjoint models (to profile very small populations) can be built using small sample sizes and that conjoint analysis can provide good data for implementing sophisticated decision support tools in non-traditional contexts. Wilcox (1999) conveyed how choice-based conjoint analysis can be used to learn how consumers evaluate key attributes of a mutual fund. The weight consumers give to fees charged by a fund can be used by fund managers to design the fee structures that will maximize utility for both the consumer and the fund manager. Clark-Murphy and Soutar (2004) use a conjoint analysis approach to investigate the attributes that influence individual investors when they make a decision to buy shares.

The next section (section 3.3.2) will provide more detail about how we selected and operationalized the attributes of the choice experiments. Section 3.4 will specify the foundations of conjoint analysis and the model applied in this study.

A number of different variations of conjoint analysis are available (Priem and Harrison, 1994; Backhaus, Erichson et al., 2006; Orme, 2007b). For example, full-profile methods such as choice-based conjoint analysis (CBC), where respondents make trade-offs between all attributes of the choice alternatives simultaneously, can be distinguished from partial profile methods such as adaptive conjoint analysis (ACA), where respondents are first asked to rank the importance of attributes followed by choice tasks that gradually build up complexity (Sawtooth Software, 2007). We decided to do an ACA survey, which is preferable over CBC in the case of smaller samples and in rather explorative settings where the key attributes of the choice situation are not obvious to the researcher ex ante (Orme, 2010a).

3.3.2 Selection of Attributes and Levels

A qualitative pre-study was carried out to learn which attributes influence the location decision of a PV project developer. For this reason, eight expert interviews (Flick, 1995) were conducted with PV project developers and other solar or project development specialists. The market professionals were asked to recount their location decision process and to explain the different influencing factors. In this way, the roles of host country characteristics as determinants in investment choice patterns, especially in regard to policy attributes, were reviewed. Based on this qualitative pre-study, an online questionnaire consisting of two parts was compiled: the ACA experiment about the importance of PV policy attributes, and questions to obtain background information about the experience and activities of the project developers and their firms.

The interviews confirmed the prominent role of policy conditions among the factors influencing a PV project investment decision. These political conditions include the availability of financial incentive schemes, the application procedure, policy targets for the future share of solar energy and the stability of support policies. Besides political conditions, legal, economic and climatic conditions were also mentioned by the interviewed experts. The legal conditions mentioned included mandatory interconnection standards, legal security and the enforcement of private property rights. Economic conditions included currency risk and electricity wholesale price. The relevant climatic condition is obviously the level of solar radiation, which directly influences a project's profitability. To reduce the number of attributes to a manageable number, we decided to exclude factors from further analysis that were relatively homogeneous among the countries studied. For example, legal security can be described as sufficiently high in the European countries we investigated, as opposed to some developing countries, which were not the focus of this study. Also, currency risk played a minor role because most of the countries considered were part of the European single currency area. As for solar resources, we decided to keep this factor constant by asking respondents to assume a solar radiation of 1,500 kWh/m^2*a. This is a realistic value for a number of the Southern European countries that attract a substantial part of the investments made by our target population of PV project developers. Apart from solar radiation, a second factor that was kept constant was the type and size of the assumed project: a greenfield solar plant with an installed capacity of 500 kW$_p$.

Based on the qualitative pre-study, five attributes were finally chosen for the ACA experiment, which reflected key factors determining the level of risk and return for investors: 'Level of tariff', 'Duration of tariff', 'Existence of a cap' (or the time until the cap is reached), 'Duration of the administrative process' and 'Policy instability' (operationalized as the number of significant unexpected policy changes in the last 5 years). Table 3.1 shows a short description of each attribute, together with the levels presented in the survey.

Table 3.1: Attributes and attribute levels used in the ACA experiment

Attributes	**Description**	**Attribute levels**				
Level of Feed-in Tariff [ct/kWh]	The amount paid per kWh fed into the grid.	31	35	38	41	45
Duration of Feed-in Tariff [years]	Number of years for which the feed-in tariff is guaranteed.	15	20	25		
Existence of a cap	Presence of a market cap limiting the promoted PV capacity, and if a cap exists, the predicted time until it will be reached.	No cap	Cap reached in 4 years		Cap reached in 1 year	
Duration of the administrative process [months]	Predicted time from the project submission until all permits are obtained.	1–2	3–6	7–12	13–18	19–24
Significant unexpected policy changes in the last 5 years	A change is considered as significant if it leads to more than 15% of feed-in tariff reduction.	0	1	3		

3.3.3 Questionnaire design

The computer-based ACA survey was designed with Sawtooth, which is the standard software solution for the design and analysis of conjoint experiments in marketing research (Sawtooth Software, 2007). At the beginning, the respondents are asked to compare attribute pairs (cf. Figure 3.1). Each question showed descriptions of hypothetical political framework conditions for two countries composed of different levels including two attributes at the beginning, then three, and then four. Assuming that the conditions were identical in all other ways, respondents should indicate which country they would preferably choose as the next project location. Rather than being asked to simply choose one or another, project developers could provide differentiated answers on a nine point scale ranging from ”strongly prefer left” to “strongly prefer right”. The number of “Paired-Comparison” questions to be asked is equal to 3*(N–n–1)–N, where N is the total number of levels and n is the total number of attributes, i.e. 3*(19–5–1)–19=20.

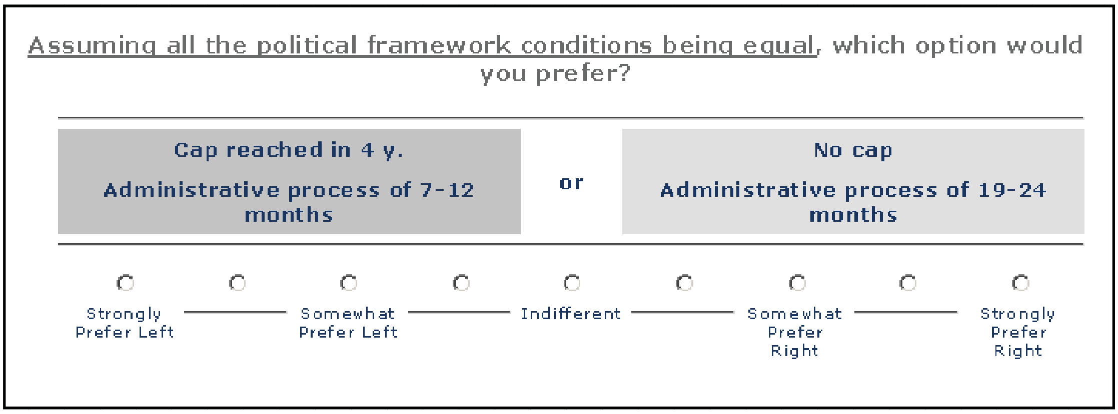

Figure 3.1: Screenshot of a “Paired-Comparison” question

In the last section, the questionnaire included a series of “Calibrating Concepts” where the product alternatives are described by levels of all attributes (cf. Figure 3.2). These concepts are calculated individually for each respondent based on his previous answers. The respondent is asked to indicate a “likelihood of choosing” between 0 and 100 about each. To assess the spread, the concept with the lowest estimated utility is presented first and then the one with the highest estimated utility.

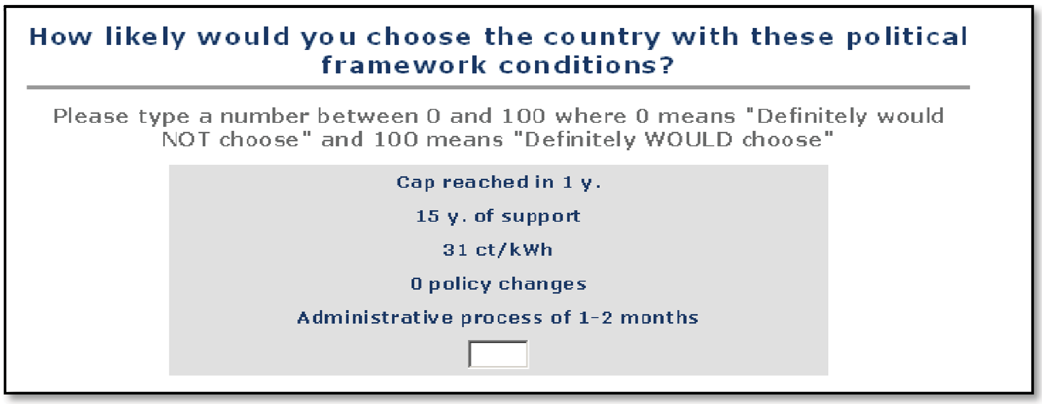

Figure 3.2: Screenshot of “Calibrating Concept“ question

3.4 Model Specification

ACA is based on the discrete choice theory (Ben-Akiva and Lerman, 1985; Train, 2009) which follows the microeconomic consumer theory. Consumer theory analyzes the economic decisions, and especially the consumption decisions, of private households. It states that a consumption decision follows a cost-benefit comparison of the different product alternatives, and that the consumer chooses the product that maximizes his utility. Lancaster (1966) advanced this theory by indicating that products can be considered as bundles of attributes, and that the utility of a product is the sum of the part-worth utilities of its attributes. However, it is not possible to completely describe any product in terms of its attributes; there will always be some unknown or intangible characteristic which may also provide utility. As a result, the other underlying foundation of discrete choice theory and conjoint analysis is Random Utility Theory (Mansky, 1977), which allows the direct utility function to be broken down into observable (deterministic) and unobservable (stochastic) parts.

This study does not evaluate the choices among products, but among policy frameworks, and thus transfers this concept to renewable energy investment. Analogous to a product, the policy framework of a country can be described as a bundle of attributes. As stated in the previous section, this study has chosen the level of return, plus a set of policy risks, as the main attributes determining project developers' choices. A utility maximizing PV project developer aims at developing a project in the country that provides the highest utility. As in the case of a choice among products, also when choosing among policy frameworks, there is an inevitable trade-off between the different attributes, and any attribute change influences the attractiveness of the respective country for the project developer. A higher level of return, for example, increases the utility and thus the attractiveness of a country whereas higher policy risks decrease the country's utility.

The utility of a policy framework U can thus be described as:

$$U = \sum_{i=1}^{m} u_i + e \tag{1}$$

where m are the different policy attributes, u_i the part-worth utilities of the different attributes and e the unknown or intangible characteristic.

The probability that a project developer i chooses the policy framework j from choice set C_t is given by the following:

$$P_{ij} = \Pr(U_{ij} \geq U_{in}; \forall j \neq n; j, n \in C_t) \tag{2}$$

where *U* is the utility of the specific policy framework and *n* are the alternative policy frameworks.

Part-worth measures the contribution of attribute levels to the overall utility of a product, i.e., the influence of a change of the respective variable on the developer's likelihood to develop a specific project. The average part-worth utilities are based on the individual part-worth utilities estimated with the hierarchical Bayes (HB) estimation model (Rossi and Allenby, 2003; Orme, 2007a) which has become the standard estimation method for conjoint analysis (Lenk, DeSarbo et al., 1996; Rossi and Allenby, 2003; Netzer, Toubia et al., 2008). Individual utilities allow assessing heterogeneity among customer segments, which is more difficult with traditional conjoint approaches based on aggregated preferences measures (e.g., standard multinominal logit (MNL) (McFadden, 1986)).

The basic idea behind the use of HB is to recognize that each individual is a member of a group of more or less similar individuals, and that knowledge of the entire distribution of individuals' part-worth utilities can enhance estimation for each individual. Individuals are assumed to be distributed multi-normally, and HB estimates the mean vector and covariance matrix for that distribution. The HB model consists of two levels. At the upper level, respondents are considered as members of a population of similar individuals (Orme, 2010b). Their part-worth utilities are assumed to have a multivariate normal distribution described by a vector of means and a matrix of variances and covariances. At the lower level, each individual's part-worth utilities are calculated by a linear regression model according to the respondent's choices within the conjoint analysis experiment. Discrepancies between actual and predicted ratings are assumed to be distributed normally and independently of one another. With several thousands of iterations (for this study, 15,000 iterations were done), each respondent's utilities are adjusted so that they reflect the optimal mix of the individual respondent ratings and the sample averages (Howell, 2009).

The utilities are interval data, meaning they are scaled to an arbitrary additive constant to sum to 0 within each attribute. Therefore a negative part-worth value for a certain attribute level does not indicate that this attribute level is unattractive per se, but it shows that it is less preferred than other levels of the same attribute with a higher part-worth value.

The relative importance of each attribute can be estimated from the ACA data by considering how much difference each attribute could make in the overall utility of the product, i.e., between the highest and the lowest utility value of each attribute. That difference is the range in the attribute's utility values. The bigger the range is, the more a variation in the attribute can lead to a variation of the overall utility (Backhaus, Erichson et al., 2006). The relative importance of each attribute is calculated using the formula (adapted from Clark-Murphy and Soutar (2004)):

$$RI_l[\%] = \frac{(MaxU - MinU)i}{\sum(Max - Min)i} x100 \tag{3}$$

where RI_i is the relative importance of attribute i; $MaxU$ the maximum utility of attribute i; and $MinU$ the minimum utility of attribute i.

The standard deviation of the individual part-worth utilities of level l is calculated using the following formula:

$$SD_l = \left[\frac{\sum_{i=1}^{n}(U_{li} - \overline{U_l})^2}{n-1}\right]^{1/2} \tag{4}$$

where SD_l is the standard deviation of the part-worth utilities of level l; U_l the part-worth utility of the attribute level l; n the number of survey participants.

The standard deviations for individual-level estimates are a measure of heterogeneity and a measure of precision. If the individual-level utilities were given without error by each respondent, there would be differences between people, due to preference heterogeneity, and thus the standard deviation would fully reflect that. But, if the people actually had the same true preferences and our estimates for each individual involved error, then, the standard deviation would directly capture the error and there would be no heterogeneity. Typical conjoint designs have nearly equal precision for each level within the same attribute because each level appears an equal number of times and the levels are orthogonal to other attributes' levels. As a result, a higher standard deviation usually reflects a higher heterogeneity of preferences.

At this point, it is important to note that the standard deviations can only be compared within the same attribute, but not between attributes, as the means can be very different; the larger the magnitude of the attribute's utility, the larger the standard deviations.

As the monetary variable feed-in tariff is included in the study, the marginal WTA certain policy risks can be derived using the formula (Orme, 2001)

$$WTA_l\left[\frac{\text{ct}}{\text{kWh}}\right] = -1(U_l - MaxU_l)\frac{\Delta FiT}{MaxFiTU} \tag{5}$$

where WTA_l is the implicit WTA of the attribute level l; U_l the part-worth utility of the attribute level l; $MaxU_l$ the maximum part-worth utility of the attribute in question; ΔFiT the difference of the level of feed-in tariff, i.e. 14ct/kWh; and $MaxFiTU$ the maximum utility of the attribute "Level of tariff".

3.5 Data and sample

The results presented in this paper are based on a unique dataset collected through an online survey conducted in October – November 2008. The population of interest for the survey was European PV project developers which were engaged in or were considering undertaking PV projects abroad in other European countries. There is no universally agreed upon definition of a project developer and his business. In general we can define three main types of firms engaged in the project development business:

- Highly specialized, typically small, firms whose exclusive business focus is to develop renewable energy projects. Due to the lack of capital or financing, they often sell the project to later-stage investors during or after the development process.
- Vertically integrated, typically larger, firms, who plan, build, own and operate renewable energy projects. They are often customers of the first group.
- A wide range of others, for whom the development of renewable energy projects is an activity outside their core business. These include electric utilities, financial investors (including banks, pension funds and insurance companies), equipment suppliers and land or building owners. Depending on their focus and risk/return expectations, they get involved in various stages of project development.

Given the wide range of players and the emerging nature of this industry, it is hard to determine an exact number for the total size of this group. The European Photovoltaic Industry Association (EPIA) membership directory lists 83 companies, but this includes firms on different parts of the value chain, including not just those involved in project development, but also manufacturers of solar cells, modules, etc. Twenty-seven of these members are active in project development. The German solar industry association, Bundesverband Solarindustrie (BSi) has 786 member firms, including not just PV firms, but also companies active in solar thermal energy. Eighty-one of these firms are categorized as solar PV project developers, but only some of them are actually investing outside of Germany and hence relevant for the purposes of this survey. Based on industry magazines and conversations with industry experts, we assume that the number of European PV project developers who engage in cross-border investments in the typical project size assumed in the survey (500 kW) is somewhat smaller in other significant PV markets such as Italy, Spain and France than in Germany. Furthermore, there are a small number of international project developers in each of a variety of other European countries including Greece, Switzerland, Austria, Benelux, Czech Republic, UK, Portugal and Scandinavia. Consequently, we estimate the size of the total target population of our study to be in the range of 200-300 project developers.

The PV project developers were solicited to participate in the survey by phone and/or e-mail, at a solar industry fair, by means of an article on an industry-specific news website (www.solarserver.de) and its newsletter and by an insert in a solar industry journal. In total, 312 invitations were made to PV project developers (some developers received multiple invitations). One hundred thirty-five respondents logged on to the survey website and 63 questionnaires were completed. The response funnel is shown in Figure 3.3. With 63 complete data sets, the final conversion rate was 20.2%. The relatively high drop-out rate may have been a result of the length of the ACA questionnaire, which took an average 20 minutes to complete – a significant time investment for a busy international manager. Each project developer completed 25 choice tasks, resulting in a final data set of 1575 choice decisions.

Stage	Number	Conversion rate
Survey invitations (totally reached persons)	**312**	
-Contacted PV project developers	130	
-Solar industry fair	32 (100)	
-Insert in solar industry journal	50 (1200)	43.3%
-Solar industry newsletter	100 (2500)	
Survey accessed	**135**	
-Contacted PV project developers	63	
-Solar industry fair	21	20.2%
-Insert in solar industry journal	23	
-Solar industry newsletter	28	46.7%
Fully completed survey	**63**	
-Contacted PV project developers	26	
-Solar industry fair	15	
-Insert in solar industry journal	8	
-Solar industry newsletter	14	

Figure 3.3: Response funnel

Table 3.2 summarizes the type, size, focus and experience of the firms in our sample, while Table 3.3 provides evidence about the geographical distribution of respondents and their firms. We intended to reach a sample that represents the descriptive statistics and geographical distribution of the total population. This could be confirmed by PV industry experts (Paris, 2010). In terms of firm type, 30.2% of respondents indicated that their firm was a specialized (early-stage) project developer, while 50.8% were vertically integrated firms. The remaining 19.0% are others, including financial investors and utilities. Regarding the stage of activity in the project development cycle, 56% of the respondents' companies are active in all stages of the project cycle, 33% in the planning, 6% in the construction and 2% in the operation and maintenance phase.

The sample is about evenly split between experienced project developers (4 or more years of experience: 44.4%) and those that are relatively new to the industry (up to 3 years of experience: 55.6%). This illustrates the emerging nature of the PV industry, but also indicates that our sample includes a substantial portion of experienced professionals. In terms of the number of projects realized, 49.2% of the interviewed persons have been involved in 1–9 projects and 39.7% in 10 or more PV projects. Seven respondents (11.1 %) had considered investments, but not actually completed a project yet. Six project developers (9.5 %) have worked on more than 100 projects. One-third of the realized projects are smaller projects with an installed capacity of less than 100 kW; 23.8% of the projects are between 100 and 500 kW; 39.7% are between 500 kW and 10 MW; and 3.2% are bigger than 10 MW. Taking a look at firm size, there is a relatively large share of small and medium-sized firms in our sample (77.8% of firms have less than 100 employees), again reflecting the entrepreneurial character of this newly emerging industry.

Table 3.3 provides some information about the geographic distribution of our sample and gives evidence of the high degree of internationalization in the sector. In terms of country of origin, German project developers represent just under half of the sample (48.0%), followed by developers from Spain (17.3%), Italy (10.7%) and several other countries. As for target countries for investments, 69.8% of the firms are active in Germany, 57.1% in Spain, 49.2% in Italy, 30.2% in Greece, 27.0% in France and 17.5% in Portugal. To ensure that our respondents were qualified to answer the choice tasks related to assessing policy frameworks, we also asked them about their familiarity with solar energy policies in those countries. The results suggest that (self-declared) policy knowledge of respondents is high, and corresponds well to the target countries they invest in: 77.8% of the interviewed PV project developers said they are familiar with the PV policy situation of Germany, 71.4% of Spain, 58.7% of Italy, 42.9% of Greece, 36.5% of France, and 19.0% of Portugal.

Table 3.2: Descriptive statistics of European PV project developers in our sample

Firm type	Specialized project developer	30.2%
	Vertically integrated project developer	50.8%
	Other (investors, utilities, etc.)	19.0%
Firm size	1-9 employees	34.9%
	10-99 employees	42.9%
	100-499 employees	15.9%
	> 500 employees	6.3%
Firm's amount of annual PV project investment (million Euros per year)	1-9 mio. €	20.6%
	10-99 mio. €	38.1%
	100-499 mio. €	19.0%
	> 500 mio. €	3.2%
	Not disclosed	19.0%
Cumulative number of projects realized	Total (entire sample)	3800
	Median (per respondent)	5
	0	11.1%
	1–9	49.2%
	10–99	30.2%
	> 100	9.5%
Average size of realized projects (installed capacity)	< 100kW	33.3%
	100-500kW	23.8%
	> 500kW	42.9%
Firm's focus of activities along the project cycle	Planning phase only	33%
	Construction phase only	6%
	Operation phase only	2%
	Full project cycle	56%
	Other	3%
Solar industry experience	1 year	27.0%
	2–3 years	28.6%
	4–6 years	27.0%
	7–9 years	6.3%
	10–12 years	6.3%
	>12 years	4.8%

Table 3.3: Geographical distribution of European PV project developers in our sample

	Country of origin (headquarter)	**Target country (investments)**	**Familiarity with country's energy policy**
Germany	48.0%	69.8%	77.8%
Spain	17.3%	57.1%	71.4%
Italy	10.7%	49.2%	58.7%
Greece	2.7%	30.2%	42.9%
France	4.0%	27.0%	36.5%
Portugal	1.3%	17.5%	19.0%
Other	16.0%	N/A	N/A

3.6 Results

R-Squared indicates the goodness of fit of the ACA/HB model. It is obtained by the regression of the “Calibration Concept” ratings over the utility scores calculated by combining the information from the “Paired-Comparison” questions of the survey. If there is good agreement in the utilities and the calibration concept ratings, then the R-squared is higher[9]. In our model, the R-squared amounts to .744, indicating a good fit.

To check the validity of the data, we included three holdout tasks in our survey (cf. Table 3.4). Holdout tasks are constructed like the concepts in the calibration section of the survey but are not used by the Sawtooth program for estimating the preferences (part-worth utilities) of the respondents. The project developers’ likelihood to invest in the respective policy frameworks can be compared with the model calculations of the investment likelihood (cf. Annex for mode of calculation)[10]. The analysis of the responses to the holdout task provides an indication of how well the utility values estimated from the ACA/HB model (indirectly stated preferences) were able to predict the respondent’s actual holdout choices (directly stated preferences). The average R-squared is .763, indicating a high validity of the results.

Table 3.4: Holdout tasks included in the survey

	Holdout 1	**Holdout 2**	**Holdout 3**
Policy Framework			
Duration admin. process (months)	1-2	19-24	13-18
Level of the FIT (ct/kWh)	35	45	41
Cap	No cap	No cap	Cap reached in 1 y.
Number of PV policy changes	0	1	1
Duration of the FIT (years)	20	20	25

In the following, we report estimation results in three steps: relative importance of attributes, part-worth utilities and project developers’ implicit willingness-to-accept certain policy risks.

[9] But, as this R-squared is often based on just a few data points (calibration ratings) from each respondent, one needs to be careful. If the respondent got confused in the calibration concept question, then even if the utilities are of good quality, their prediction of calibration concept responses would be bad.

3.6.1 Relative Importance of attributes

Using Equation (3), the relative importance of attributes can be calculated. Results are displayed in Table 3.5. The two most important attributes in our model are duration of the administrative process (25.6%) and level of the feed-in tariff (24.4%). The existence of a cap and the number of PV policy changes are of medium importance with 18.7% and 17.7%, respectively. The lowest importance (13.6%) is attributed to the duration of the feed-in tariff.

Table 3.5: Relative importance of attributes

Attribute	Average Importance	Std. Dev.
Duration admin. process	25.56 %	2.99035
Feed-in Tariff level	24.37%	2.81874
Cap	18.72%	3.94464
Solar policy changes	17.74%	3.55881
Feed-in Tariff duration	13.61%	3.43082

3.6.2 Part-worth utilities

Average part-worth utilities, standard deviations, standard errors and t-values (ratio of mean to standard error) for each attribute level are displayed in Table 3.6. A t-test has been applied to test if part-worth utilities are statistically different from zero. The part-worth utility analysis confirms that there is a positive monotonic relationship between attribute levels and utility, indicating that all else being equal, respondents consistently preferred choice alternatives with higher levels for each attribute. Standard deviations are generally low, with some exceptions for extreme attribute levels. The low distribution is also confirmed by an analysis of the correlations. Correlation coefficients of all respondents were close to 1 (0.95 – 0.99).

Table 3.6: Mean part-worth utility estimates (Diffs), standard deviations, standard errors and the ratio of mean to standard error by attribute levels (Hierarchical Bayes Model with normally distributed part-worth utilities)

Attribute	**Attribute level**	Mean Part-worth utility (Diffs)	Standard Deviation	Standard Error (St.Er.)	Ratio of Mean to Standard Error (Mean/St.Er.)
Level of Feed-in Tariff	**31 ct/kWh**	0	-	-	-
	35 ct/kWh	35.4780953***	4.70325067	0.59255389	59.8731965
	38 ct/kWh	62.4197534***	6.99389399	0.88114782	70.8391396
	41 ct/kWh	90.9913517***	11.2727612	1.42023441	64.0678404
	45 ct/kWh	122.009056***	13.8322346	1.74269776	70.0115986
Duration of Feed-in Tariff	**15 y. of support**	0	-	-	-
	20 y. of support	37.5409818***	14.8937234	1.87643277	20.0065691
	25 y. of support	67.441007***	16.9823673	2.13957717	31.5207172
Existence of a cap	**No cap**	93.5598085***	19.7885856	2.49312744	37.5270862
	Cap reached in 4 y.	53.3365727***	17.1485026	2.16050825	24.6870488
	Cap reached in 1 y.	0	-	-	-
Duration of the administrative process	**Administrative process of 1-2 months**	128.271172***	14.5938479	1.83865201	69.7637024
	Administrative process of 3-6 months	96.143963***	13.4832766	1.69873318	56.597448
	Administrative process of 7-12 months	65.6771283***	11.5117182	1.45034017	45.2839476
	Administrative process of 13-18 months	33.4183901***	7.39185858	0.93128664	35.8841076
	Administrative process of 19-24 months	0	-	-	-
Significant unexpected policy changes in the last 5 years	**0 policy changes**	88.7189569***	17.7522899	2.2365783	39.6672708
	1 policy change	53.4732229***	16.0798192	2.0258668	26.3952314
	3 policy changes	0	-	-	-

***statistically different from zero at significance level of 0.01

3.6.3 Project Developers' implicit Willingness-to-Accept certain Policy Risks

In a next step, to facilitate interpretation of results and comparison of utilities across attributes, we calculated project developers' willingness-to-accept (WTA) certain policy risks using Equation (5). Results are presented in Figure 3.4 and briefly discussed below.

The choice experiments included three attribute levels regarding the *existence of a cap*: no cap, a cap that is going to be reached in 4 years (loose cap), and a cap that is going to be reached in 1 year (tight cap). The analysis shows that removing a loose (tight) cap will allow governments to attract the same level of investment at a feed-in tariff that is about 4.71 (10.94) ct/kWh lower than in the base case. Regarding the policy risk *duration of the administrative process*, Figure 3.4 shows that for every half-year increase in the duration of the administrative process, a government must pay project developers a feed-in tariff premium of 3.68 ct/kWh (all else being equal). With regard to *policy stability*, the study estimates that compared to full policy stability, in low risk conditions (one significant unexpected policy change in the last 5 years) the feed-in tariff needs to be 4.10 ct/kWh higher, whereas in high risk conditions (three significant unexpected policy changes in the last 5 years) a price premium of 10.28 ct/kWh will be required to maintain the same level of attractiveness. Finally, the *duration of the support* is also associated with a price tag. If the duration of a feed-in tariff is reduced from 25 to 15 years, the incentive needs to be 7.86 ct/kWh higher as compensation.

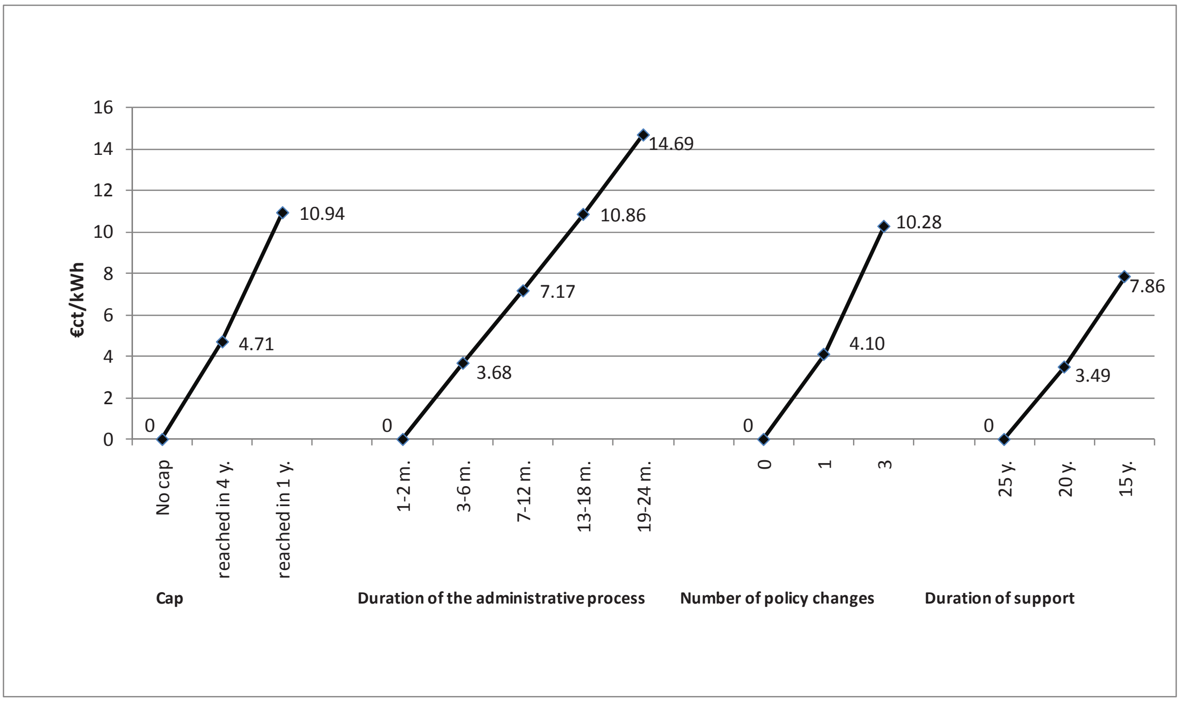

Figure 3.4: Willingness–to-accept certain policy risks

The risks analyzed in this study relate differently to developers' business models. While unexpected policy changes relate directly to policy risks, the existence of a cap and longer administrative processes might also have an effect on the project net present value. In the case of the existence of a cap, besides the risk of not knowing when and if at all one will be able to take advantage of a feed-in tariff, there could also be costs associated with either having to wait until one gets accepted or rejected after having already made some investments. Long administrative processes are a source of risk, as a long process may imply a greater risk of refusal, but they also have a direct negative effect on project net present value by increasing the time between incurring initial costs and receiving returns. In interviews with PV project developers, we found that costs for longer administrative durations are very different for each project and depend on many project and company details such as the laws in the specific country, project partners, size of the company, etc. The most important cost points are the following:

1) Expenditures already incurred like personal and infrastructure costs, company financing costs and material costs (in the case of long term material agreements). If the expenditures have been incurred as liabilities, additional interest need to be paid; if it is owner's equity, there are opportunity costs.

2) Lower financial support (e.g., in the case of a FIT with yearly degression)

3) Additional economic loss can occur if the land lease agreement is limited in time.

Additionally, there are some risks for further losses, like a change of the support policy, the tax law or increasing raw material prices.

3.7 Conclusion

3.7.1 Summary and implications for policy makers

Achieving energy policy objectives depends on whether public policy effectively influences investor behavior. In the specific case of feed-in tariffs for solar PV, there has been substantial policy experimentation and learning over recent years, but how investors react to certain policy attributes has been a black box until now. We have opened this black box by conducting a stated-preference survey among European project developers investing in solar energy across different countries.

Contributing to a growing research stream that uses choice experiments in energy economics, this study is one of the first empirical contributions that investigates the influence of renewable energy policies on project developers' decisions. Transferring a particular version of choice experiments that has proven successful in marketing research (adaptive conjoint analysis) to energy economics research, we determined the relative importance of certain policy risks and quantified the premium demanded by project developers to accept those risks. On a solid empirical basis, our research allows policy makers to assess the costs and benefits of reducing various elements of policy risk.

Overall, these findings confirm the importance of "non-economic" barriers – such as duration of the administrative process and political instability – to the deployment of renewable energy and thus demonstrate that risk matters in PV policy design. Project developers in our sample perceived the duration of the administrative process, followed by the level of the feed-in tariff, as the most important attributes in the decision to invest in solar energy projects in a given country. We extended previous research by showing that a price tag can be attached to specific policy risks. This allows policy-makers to quantify and prioritize the influence of specific policy risks on investment behavior. This study shows that accelerating administrative process, removing a cap, increasing policy stability and/or increasing the duration of support are important ways in which policy-makers can increase their country’s attractiveness for renewable energy investors. For each of those policy risks, our empirical results provide evidence for the level of risk premium that PV project developers will demand.

Governments can build on these findings to design policies that will be effective in attracting PV investment, while at the same time maintaining efficiency by providing an adequate compensation for policy risk. In particular, policy-makers should be aware that long administrative processes and, to a somewhat lesser extent, policy risks related to the existence of a cap and a substantial number of unexpected policy changes, have an attached cost that will need to be reflected in a higher level of feed-in tariffs to attract solar project developers.

3.7.2 Limitations and further research

Being one of the first of its kind in empirically investigating the reactions of international renewable energy project developers to policy risk with choice experiments, this study is subject to some limitations that provide starting points for further research.

First of all, our findings on the relative importance of different policy attributes in explaining the decision to invest in a given country is obviously limited to those attributes included in our experimental design. While the careful selection of attributes based on qualitative expert interviews gives us confidence that we have indeed picked relevant attributes for the choice situation under consideration, unobserved factors may play a role, particularly when it comes to transferring our findings to different contexts, such as renewable energy investment in emerging or developing countries. We would particularly highlight aspects of overall political stability, currency risk or legal security, which we did not include in our study because they are sufficiently similar within the European countries we investigated. Other unobserved factors include language, country size, personal contacts and social acceptance of the new technology (Wüstenhagen, Wolsink et al., 2007). We have decided not to include those factors in our choice experiments because they can only be influenced by policy-makers to a limited extent, but it seems plausible that they would also play a role. For example, all else being equal, a project developer may consider the fixed cost of starting operations in a large country like Spain more worthwhile than in a small country like Cyprus. These potential moderating factors should be kept in mind when interpreting our results.

The second limitation of our study is the size of our sample. Our sample consists of 63 early-stage European project developers conducting 25 choice tasks each, resulting in a total of 1575 observations. As a result, the sample does not allow the creation of subsamples to investigate regional, developer type or company size specific preferences or to control for regional effect as 50% of the respondents are located in Germany. Out of the family of choice experimental methodologies, we have used ACA as it is particularly suitable for smaller sample sizes, and we are well within the range of minimum sample sizes recommended in the ACA literature. Nevertheless, further research should aim at validating our findings with larger sample sizes, with other types of investors (e.g., later-stage project financiers) or in other geographic regions (e.g., North America, Asia). We would note that when other researchers pick up on this suggestion, they should be conscious of the quality and consistency of the sample. The target population of our survey was a set of professional, real-world decision makers in an early-stage growth market. Thus, unlike surveys in more mature markets or with consumer or student samples, recruiting will inevitably remain a key challenge for follow-up research on renewable energy project developers.

A third limitation is that our results are based on stated preference data. We have consciously chosen a stated preference design to address some of the challenges of doing an analysis of revealed preferences in an early-stage growth market, such as the absence of sufficiently long time series and the difficulty in disentangling the importance of different policy attributes in explaining aggregate outcomes (such as installed capacity). However, future research should further explore the possibility of comparing our findings with revealed preference data, especially as feed-in tariffs continue to spread across more countries and longer time series become available.

A fourth limitation lies in our operationalization of policy stability. Our model and findings suggest that less policy changes are better, which is in line with previous research highlighting the importance of stable framework conditions for effective deployment policies for renewable energy, and this makes intuitive sense in cases where successful policies have been changed with negative consequences for renewable energy investment flows. On the other hand, there are situations in several countries where existing policies are clearly ineffective, such as Switzerland's feed-in tariff for solar energy, where an extremely tight cap led to a waiting list of 3000 projects immediately after the policy had been introduced. It would be a misinterpretation of our findings to suggest that such ineffective policies should be kept constant. Instead, the positive valuation of policy stability that we and others have identified seems to suggest that policy-makers should conduct such changes with care and in a predictable manner and that it is a good idea to reduce the frequency of changes to a necessary minimum. Finally, there also is empirical evidence for non-linear reactions to policy stability, whereby announced policy changes initiate a boom-bust cycle. A prime example of this is the Spanish market for PV, which collapsed in 2009 due to policy changes, but this was preceded by a record year of installations in 2008 as international project developers rushed to Spain to implement their projects ahead of the expected changes. Our model and findings fail to explain such short-term cycles. While it is questionable whether they are desirable from a long-term policy perspective, such phenomena certainly provide interesting opportunities for further research taking a behavioral finance perspective.

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3.9 Annex: Purchase Likelihood Calculation

Sawtooth offers the simulation method "Purchase Likelihood" (*SMRT Simulation*) to estimate the level of interest for a certain combination of attribute levels. The utilities are scaled so that an inverse logit transform provides estimates of purchase likelihood, as expressed by the respondent in the calibration section of the questionnaire. The simulator estimates how each respondent might have answered if presented with any concept in the calibrating section of the interview. The likelihood projection is given on a 0 to 100 scale.

This method can be used to investigate the likelihood of project developers to invest in a certain country (i.e. a specific combination of attribute levels). Using a combination of attribute levels from the conjoint design it is possible to simulate the effective market framework in a certain country. Based on the results of the conjoint analysis it will then be possible to define the likelihood that an investor will invest in a specific country.

Likelihoods are estimated for policy frameworks by summing scaled utilities and estimating probabilities with the following transformation:

$$p = \frac{e^u}{1 + e^u}$$

where p is probability of investment, e the constant e and u the policy frameworks utility.

3.10 Supporting Material

3.10.1 Affiliations of Interviewed Experts

- CEO Solarsquare AG, Switzerland
- President of the European Photovoltaic Industry Association (EPIA)
- Key Account Manager, Phoenix Solar AG, Germany
- Senior Manager, Renewable Energies & Resources, Invest in Germany GmbH, Germany
- Managing Director of Epuron Italy
- Sales Manager, alfasolar, Germany
- Vestas Graduate CSR, Germany
- Project Manager at European Solar Farms, Denmark

3.10.2 Expert Interview Questions

- Questions about the expert:
  - Who are you? How are you involved in solar energy project development?
  - In which elements of the value chain are you active (e.g., project development/ financial engineering/ construction, etc.)
  - What kind of projects are you developing? Of what size and type (integrated, free field, island, mainland, on-grid, off-grid)?
  - In which countries are you active?
- Questions about the business/financing practice:
  - What is your project development process?
  - Which is/are your market entry strategy/-ies?
  - What defines your decision where to enter the market? What are the different risk and return factors and their importance? (quantify these factors)
  - How will the PV market develop in the next years? (Regarding supply and demand, module prices, grid parity etc.)
- Questions about policy effectiveness:
  - What are the most important public financial support factors?
  - How important are the following factors?
    - Numbers of applications, the number of involved authorities?
    - Maximal, minimal and mean lead-time? Is there a big variation? How important is the lead-time and the variation of the lead-time?
  - What is the percentage of approved applications? Can one generalize: if the percentage of applications goes down, the probability of success goes down?

3.10.3 Example of the adaptive conjoint analysis (ACA) online survey

The following print screens provide an exemplary survey.

In the first part, you will be asked to make **tradeoff decisions** between hypothetical location choices.

In the second part of the survey, you will be asked about the **likelihood** that your company would choose a proposed location country based on a hypothetical scenario.

In the third part, you should indicate **how relevant** certain factors are in making a location decision.

In the last part, we are asking you some questions about **your working position and experience**.

Please assume that your company is looking for a location country for a new **greenfield** solar project of a **capacity of 300 kW**. All countries to choose from have a **solar radiation of 1500 kWh/m2**.

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During this survey, we are going to ask you to consider policy framework features of a country that you might choose to locate your new solar plant.

The policy frameworks might differ in terms of:

- TARIFF LEVEL: The amount paid per kWh feed into the grid
- TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed
- TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
- DURATION OF THE ADMINISTRATIVE PROCESS: Time period from the project submission until all permits are obtained
- SIGNIFICANT UNEXPECTED NEGATIVE SOLAR POLICY CHANGES IN THE LAST 5 YEARS: A change is considered as significant if it leads to more than 15% of feed-in tariff reduction for new installed capacities

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In this first section, we will make up some different alternatives for you to consider. In each question we present two political frameworks, each described by combinations of features. One is shown on the left side of the screen, and the other on the right. Please indicate **which framework you would prefer**, and indicate **your strength of preference.**

We will only be asking you to compare a few features at a time. Please assume that the alternatives are identical in all other ways.

Assuming all the political framework conditions being equal, which option would you prefer?

45 ct/kWh 20 y. of support	or	41 ct/kWh 25 y. of support

Strongly Prefer Left — Somewhat Prefer Left — Indifferent — Somewhat Prefer Right — Strongly Prefer Right

- TARIFF LEVEL: The amount paid per kWh feed into the grid.
- TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
- TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
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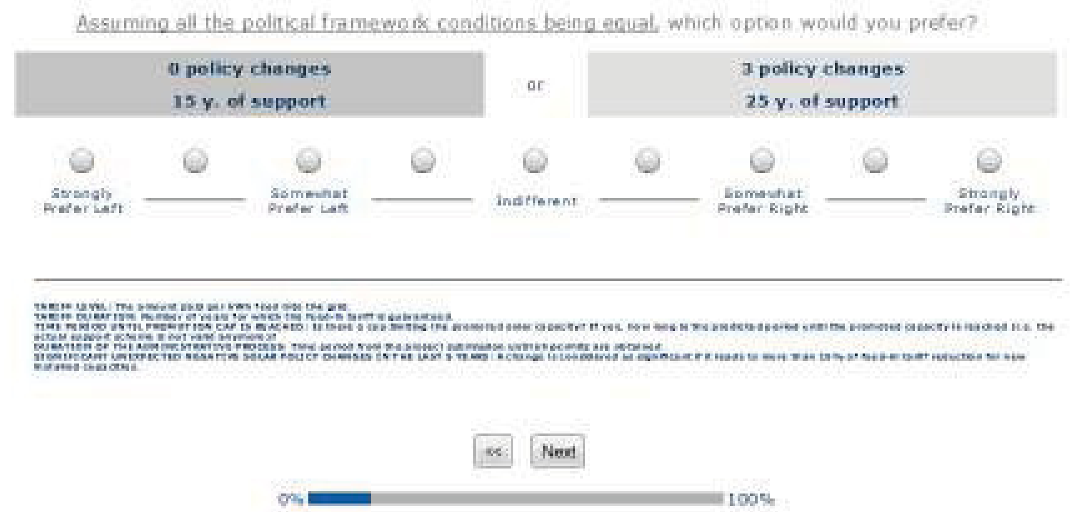
Assuming all the political framework conditions being equal, which option would you prefer?
0 policy changes
15 y. of support
or
3 policy changes
25 y. of support
Strongly Prefer Left
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Indifferent
Somewhat Prefer Right
Strongly Prefer Right
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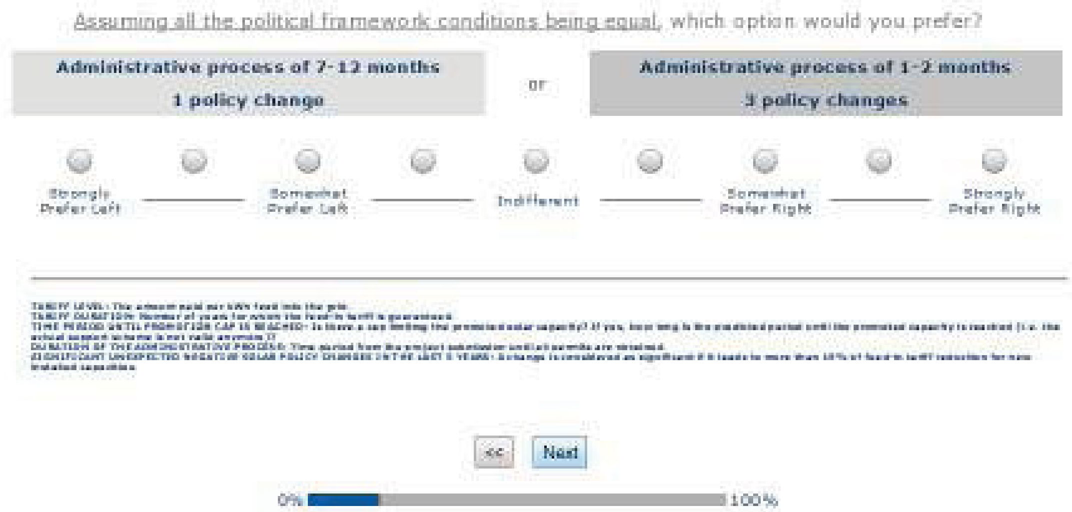
Assuming all the political framework conditions being equal, which option would you prefer?
Administrative process of 7-12 months
1 policy change
or
Administrative process of 1-2 months
3 policy changes
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
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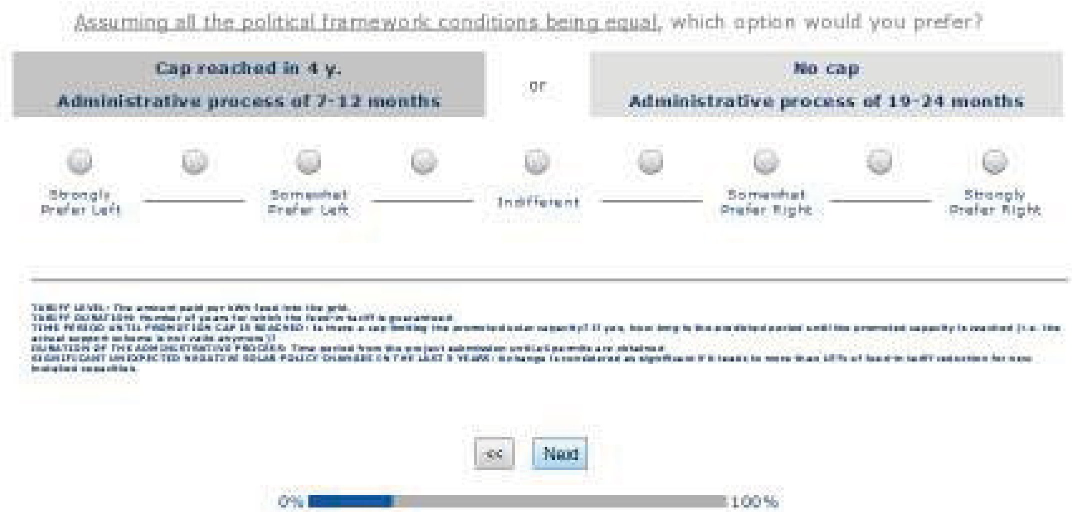
Assuming all the political framework conditions being equal, which option would you prefer?
Cap reached in 4 y.
Administrative process of 7-12 months
or
No cap
Administrative process of 19-24 months
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
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Strongly Prefer Right
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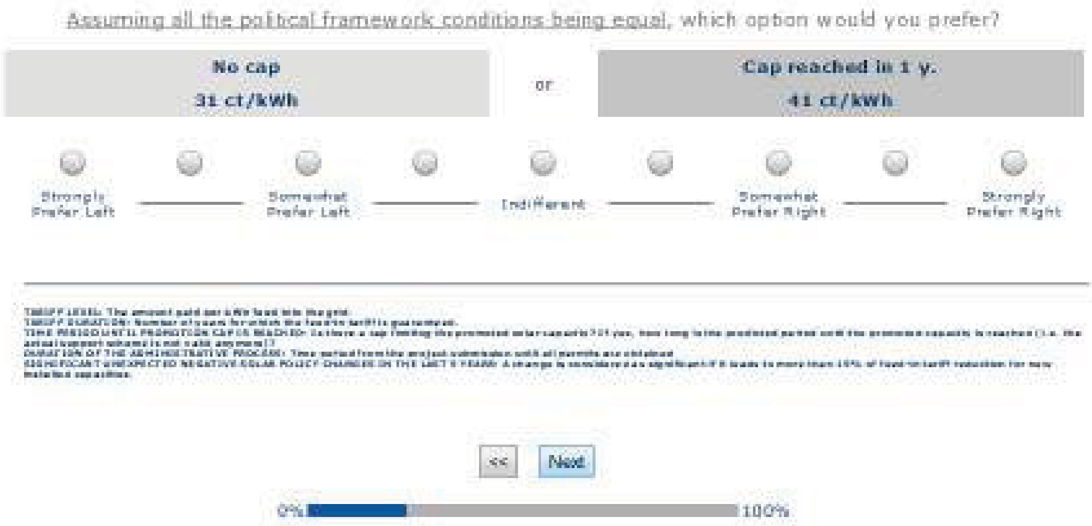
Assuming all the political framework conditions being equal, which option would you prefer?
No cap
31 ct/kWh
or
Cap reached in 1 y.
41 ct/kWh
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
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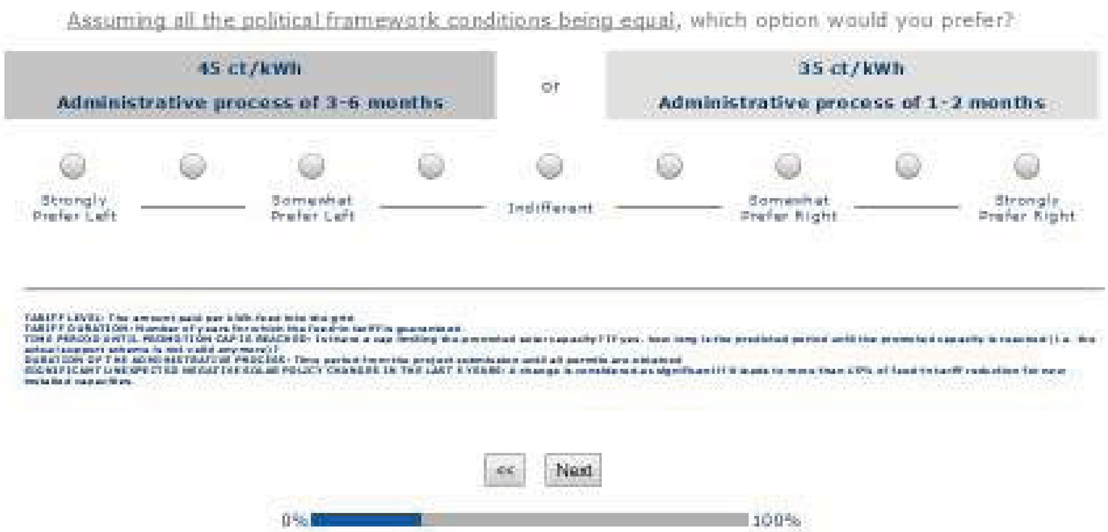
Assuming all the political framework conditions being equal, which option would you prefer?
45 ct/kWh
Administrative process of 3-6 months
or
35 ct/kWh
Administrative process of 1-2 months
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
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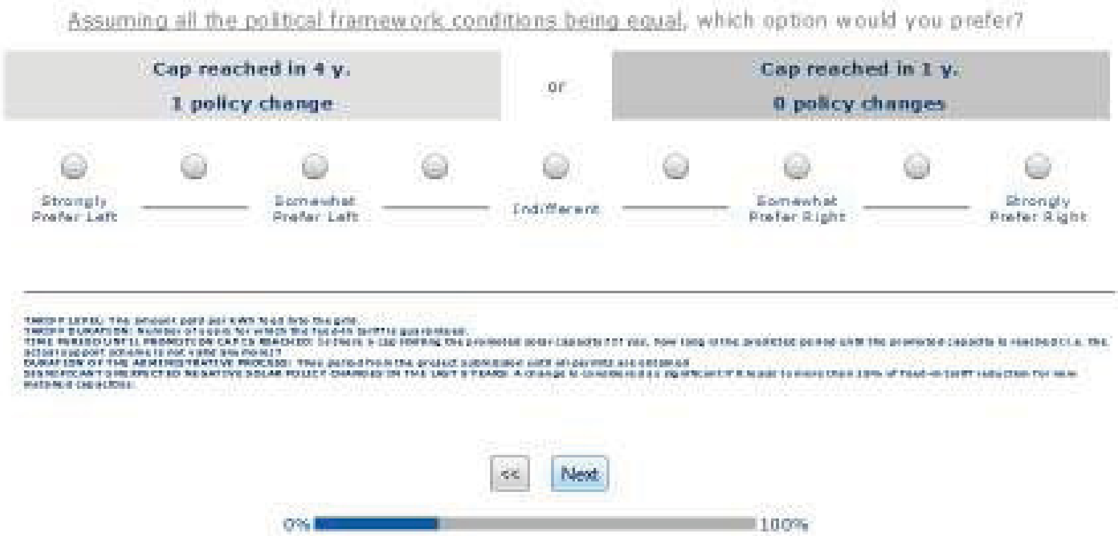
Assuming all the political framework conditions being equal, which option would you prefer?
Cap reached in 4 y.
1 policy change
or
Cap reached in 1 y.
0 policy changes
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
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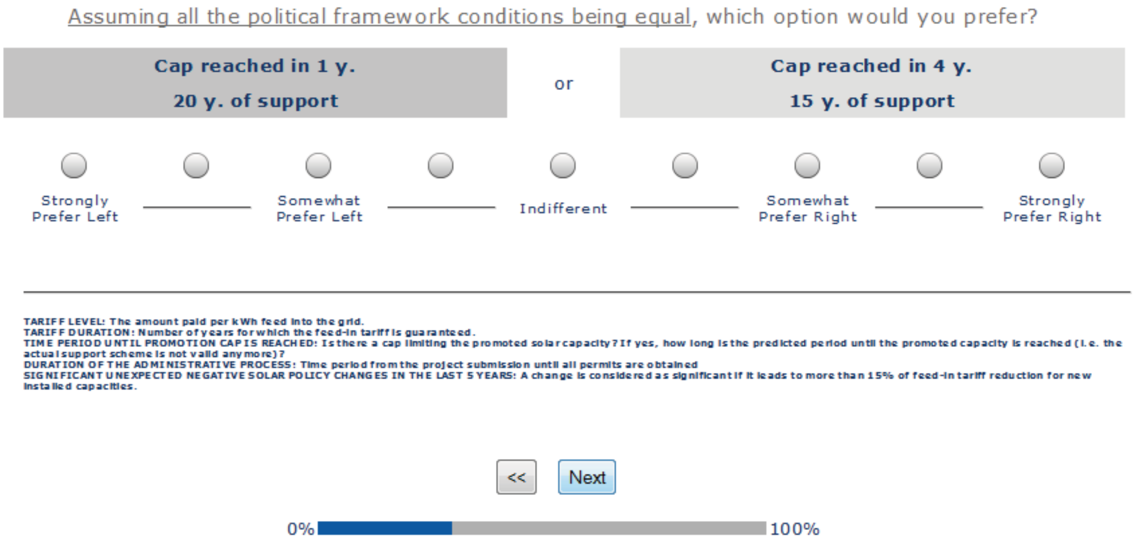

Assuming all the political framework conditions being equal, which option would you prefer?

Cap reached in 1 y. 20 y. of support	or	Cap reached in 4 y. 15 y. of support

Strongly Prefer Left — Somewhat Prefer Left — Indifferent — Somewhat Prefer Right — Strongly Prefer Right

TARIFF LEVEL: The amount paid per kWh feed into the grid.
TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
DURATION OF THE ADMINISTRATIVE PROCESS: Time period from the project submission until all permits are obtained
SIGNIFICANT UNEXPECTED NEGATIVE SOLAR POLICY CHANGES IN THE LAST 5 YEARS: A change is considered as significant if it leads to more than 15% of feed-in tariff reduction for new installed capacities.

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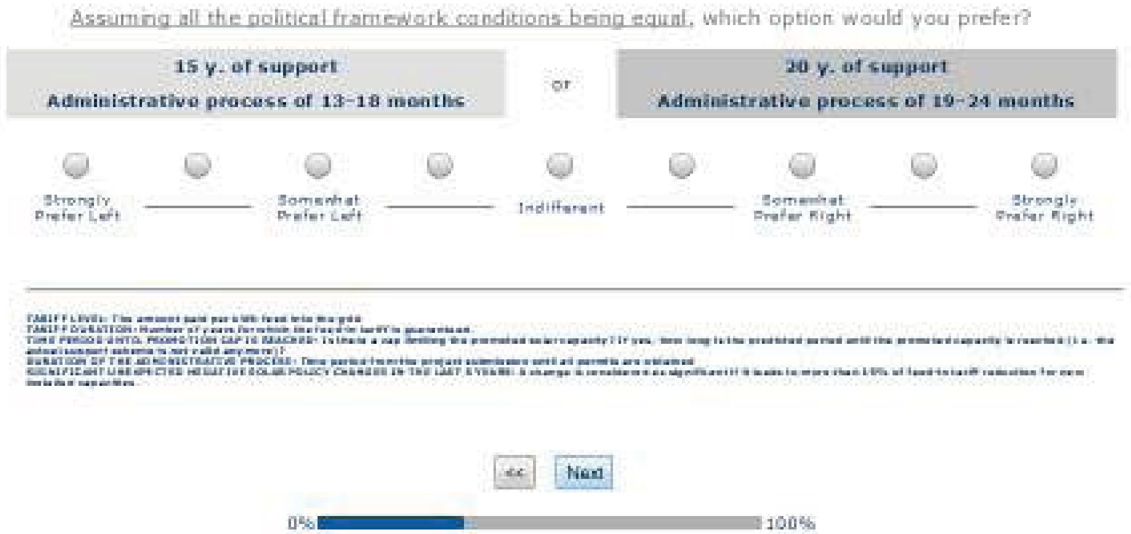

Assuming all the political framework conditions being equal, which option would you prefer?

15 y. of support Administrative process of 13-18 months	or	20 y. of support Administrative process of 19-24 months

Strongly Prefer Left — Somewhat Prefer Left — Indifferent — Somewhat Prefer Right — Strongly Prefer Right

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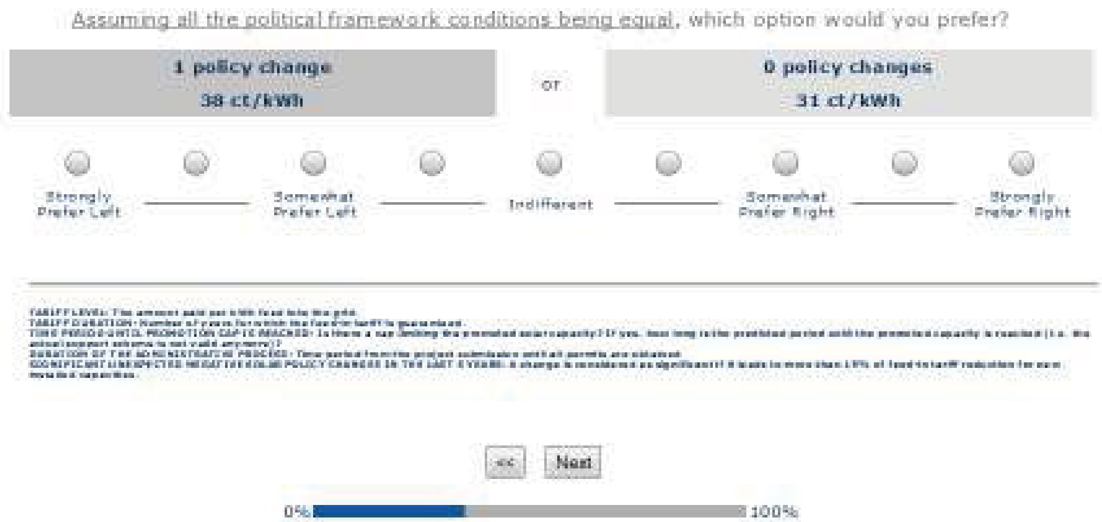

Assuming all the political framework conditions being equal, which option would you prefer?

1 policy change 38 ct/kWh	or	0 policy changes 31 ct/kWh

Strongly Prefer Left — Somewhat Prefer Left — Indifferent — Somewhat Prefer Right — Strongly Prefer Right

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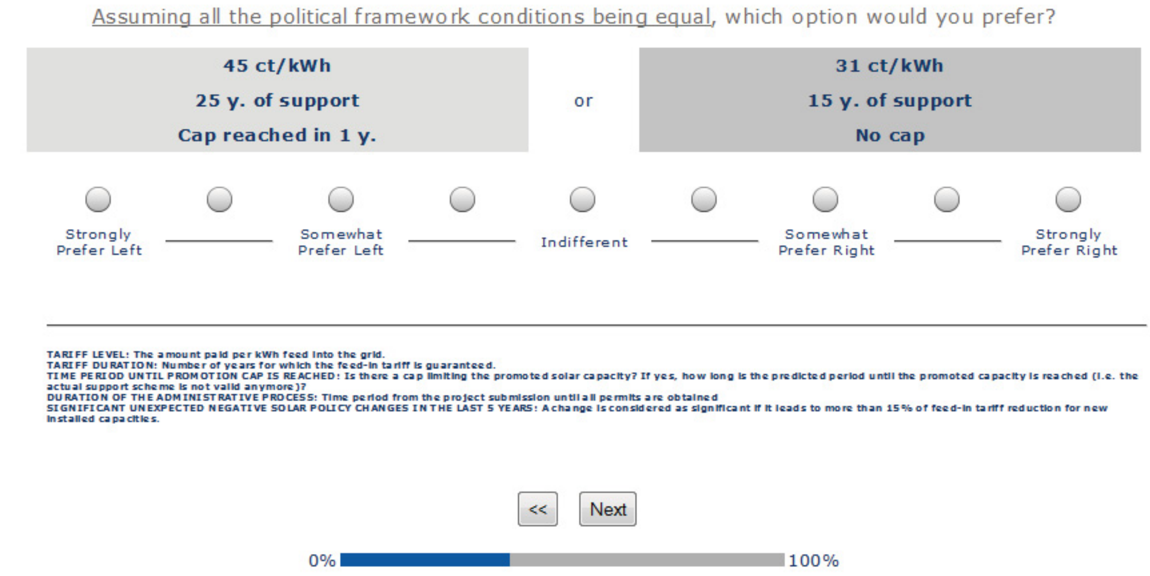
Assuming all the political framework conditions being equal, which option would you prefer?
45 ct/kWh
25 y. of support
Cap reached in 1 y.
or
31 ct/kWh
15 y. of support
No cap
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
TARIFF LEVEL: The amount paid per kWh feed into the grid.
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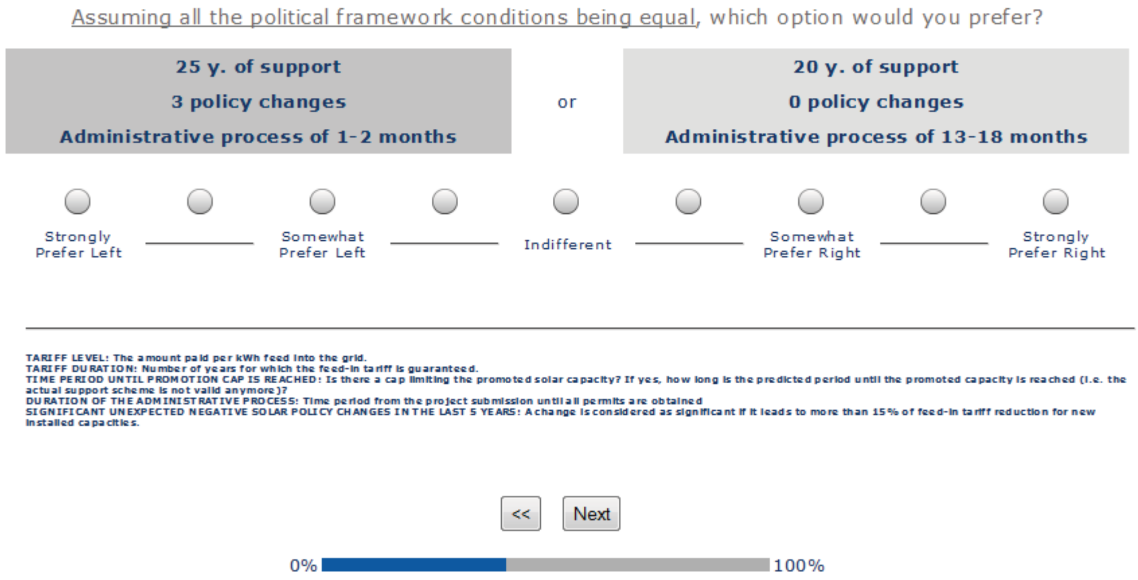
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25 y. of support
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Administrative process of 1-2 months
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Somewhat Prefer Left
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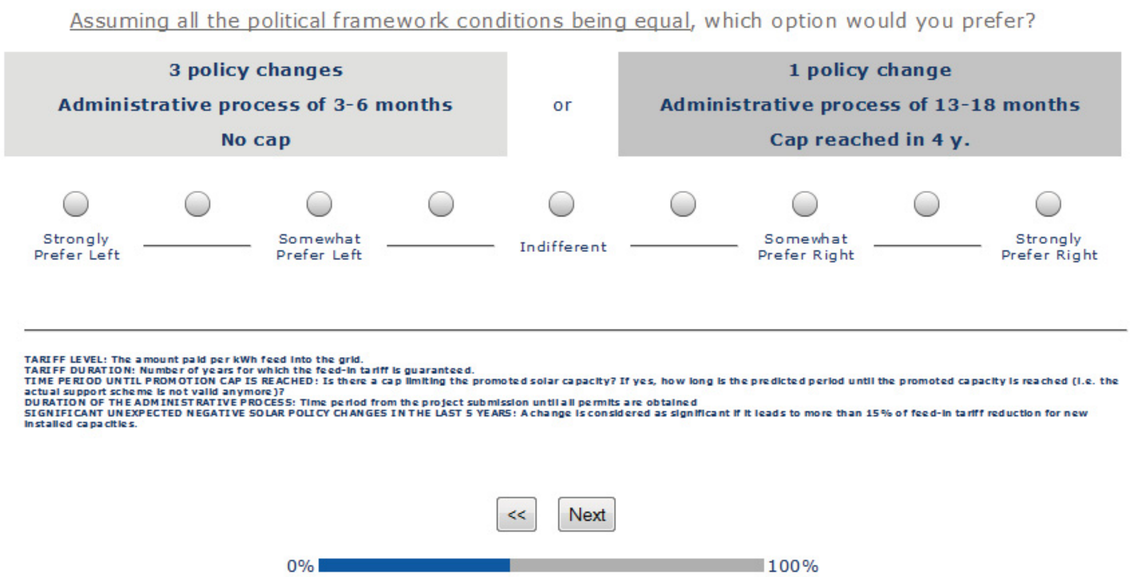
Assuming all the political framework conditions being equal, which option would you prefer?
3 policy changes
Administrative process of 3-6 months
No cap
or
1 policy change
Administrative process of 13-18 months
Cap reached in 4 y.
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
TARIFF LEVEL: The amount paid per kWh feed into the grid.
TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
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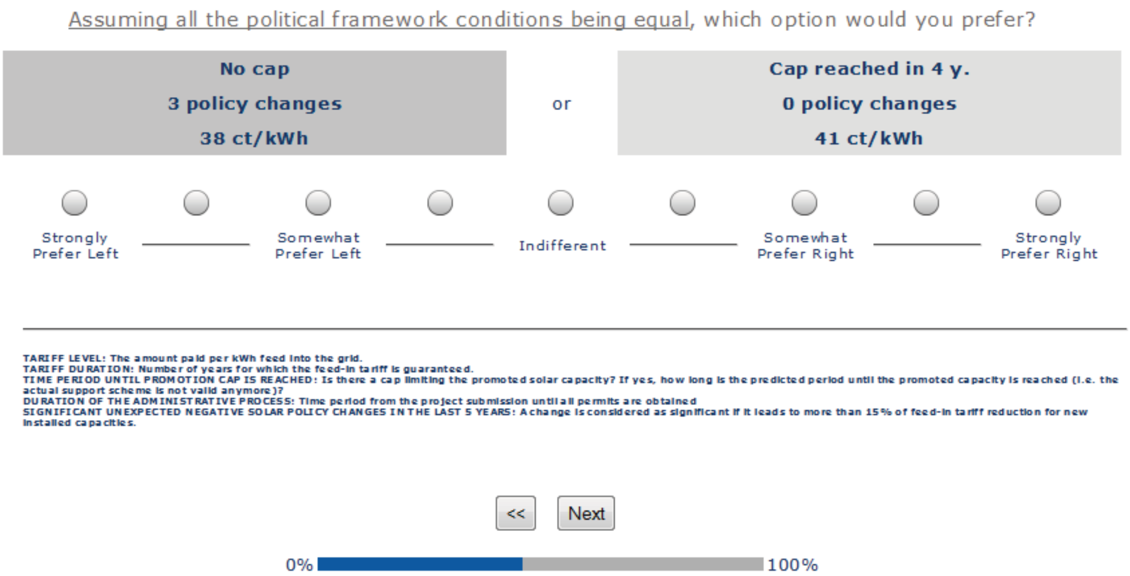
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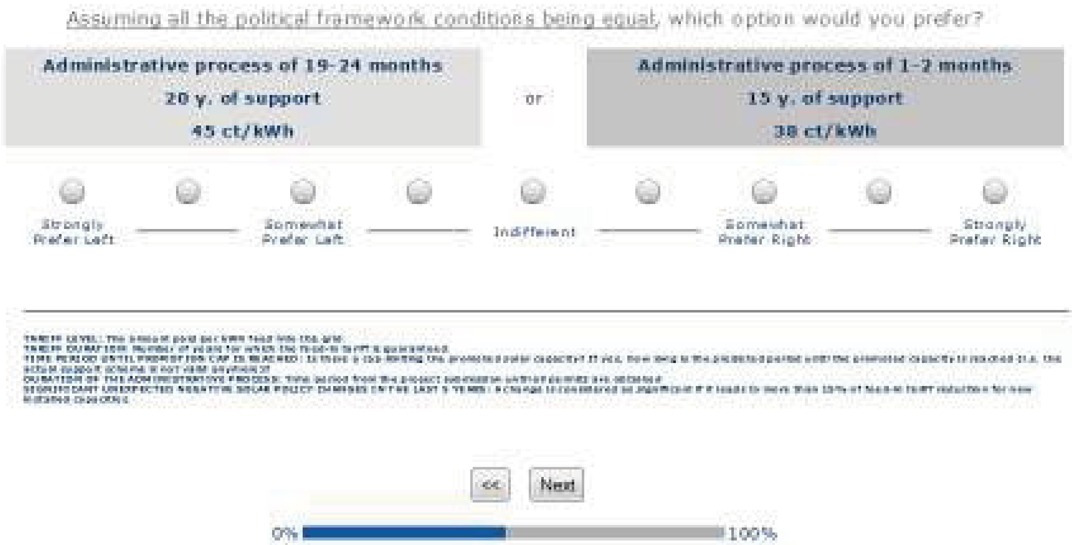
38 ct/kWh
or
Cap reached in 4 y.
0 policy changes
41 ct/kWh
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
TARIFF LEVEL: The amount paid per kWh feed into the grid.
TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
DURATION OF THE ADMINISTRATIVE PROCESS: Time period from the project submission until all permits are obtained
SIGNIFICANT UNEXPECTED NEGATIVE SOLAR POLICY CHANGES IN THE LAST 5 YEARS: A change is considered as significant if it leads to more than 15% of feed-in tariff reduction for new installed capacities.
<<
Next
0%
100%


Assuming all the political framework conditions being equal, which option would you prefer?
Administrative process of 19-24 months
20 y. of support
45 ct/kWh
or
Administrative process of 1-2 months
15 y. of support
38 ct/kWh
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
<<
Next
0%
100%


Assuming all the political framework conditions being equal, which option would you prefer?
35 ct/kWh
No cap
Administrative process of 19-24 months
or
31 ct/kWh
Cap reached in 1 y.
Administrative process of 3-6 months
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
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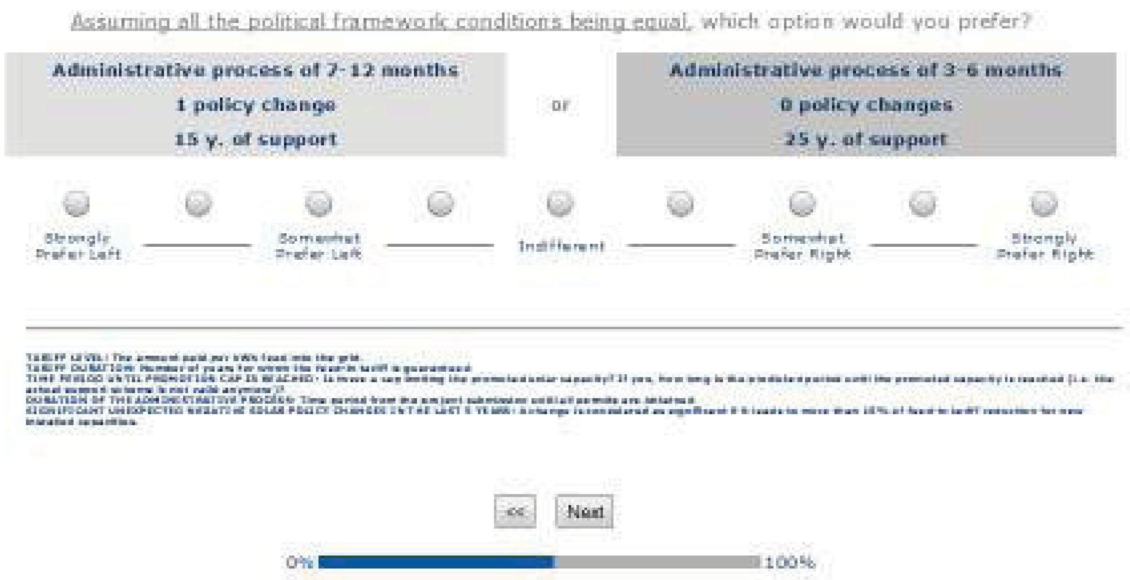
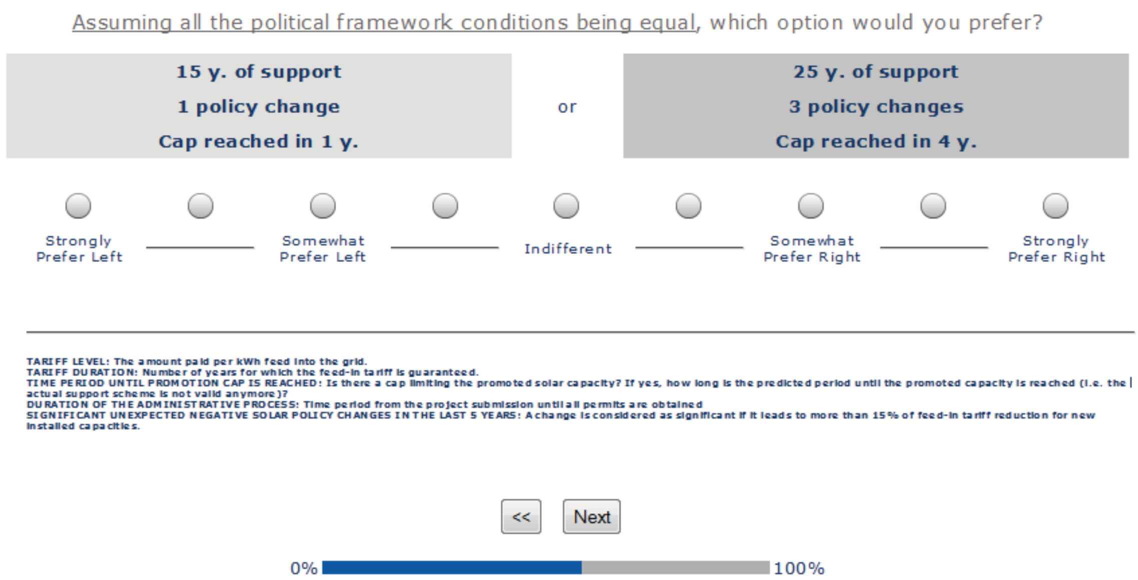

Assuming all the political framework conditions being equal, which option would you prefer?
Administrative process of 7-12 months
1 policy change
15 y. of support
or
Administrative process of 3-6 months
0 policy changes
25 y. of support
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
<<
Next
0%
100%


Assuming all the political framework conditions being equal, which option would you prefer?
25 y. of support
35 ct/kWh
1 policy change
or
20 y. of support
38 ct/kWh
3 policy changes
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
<<
Next
0%
100%


Assuming all the political framework conditions being equal, which option would you prefer?
15 y. of support
1 policy change
Cap reached in 1 y.
or
25 y. of support
3 policy changes
Cap reached in 4 y.
Strongly Prefer Left
Somewhat Prefer Left
Indifferent
Somewhat Prefer Right
Strongly Prefer Right
TARIFF LEVEL: The amount paid per kWh feed into the grid.
TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
DURATION OF THE ADMINISTRATIVE PROCESS: Time period from the project submission until all permits are obtained
SIGNIFICANT UNEXPECTED NEGATIVE SOLAR POLICY CHANGES IN THE LAST 5 YEARS: A change is considered as significant if it leads to more than 15% of feed-in tariff reduction for new installed capacities.
<<
Next
0%
100%

Assuming all the political framework conditions being equal, which option would you prefer?

20 y. of support 35 ct/kWh Administrative process of 13-18 months	or	25 y. of support 41 ct/kWh Administrative process of 7-12 months

Strongly Prefer Left — Somewhat Prefer Left — Indifferent — Somewhat Prefer Right — Strongly Prefer Right

TARIFF LEVEL: The amount paid per kWh feed into the grid.
TARIFF DURATION: Number of years for which the feed-in tariff is guaranteed.
TIME PERIOD UNTIL PROMOTION CAP IS REACHED: Is there a cap limiting the promoted solar capacity? If yes, how long is the predicted period until the promoted capacity is reached (i.e. the actual support scheme is not valid anymore)?
DURATION OF THE ADMINISTRATIVE PROCESS: Time period from the project submission until all permits are obtained
SIGNIFICANT UNEXPECTED NEGATIVE SOLAR POLICY CHANGES IN THE LAST 5 YEARS: A change is considered as significant if it leads to more than 15% of feed-in tariff reduction for new installed capacities.

<< Next

0% 100%

Based on your previous responses, we are making up some combinations of political framework features for you to consider.

We will ask you **how likely you would be to choose each combination** if it was available right now.

How likely would you choose the country with these political framework conditions?

Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"

Administrative process of 19-24 months

Cap reached in 1 y.

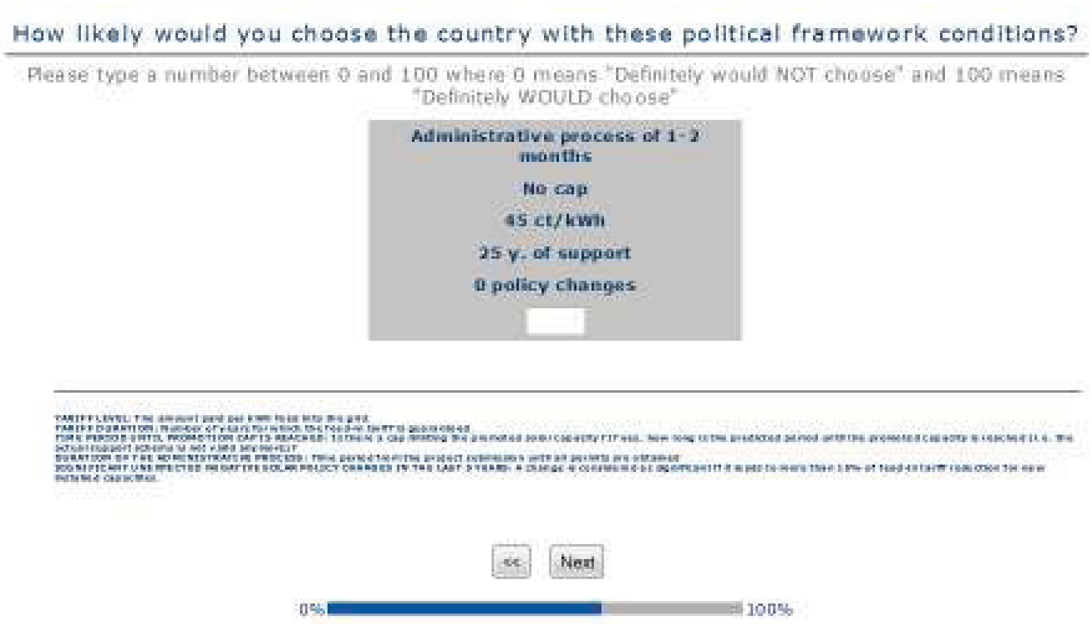
31 ct/kWh

15 y. of support

3 policy changes

<< Next

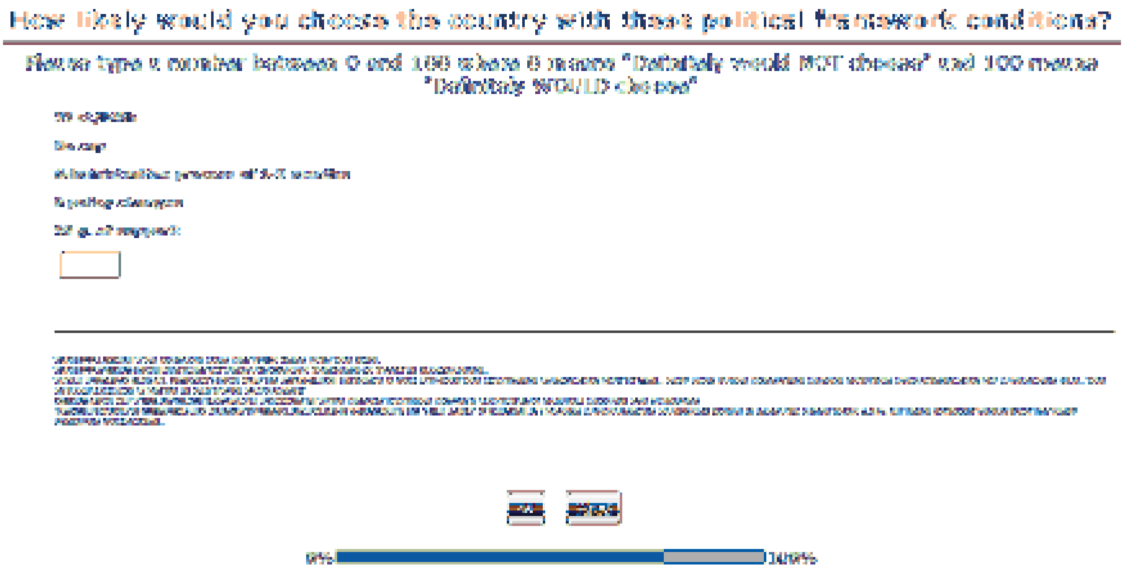
0% 100%

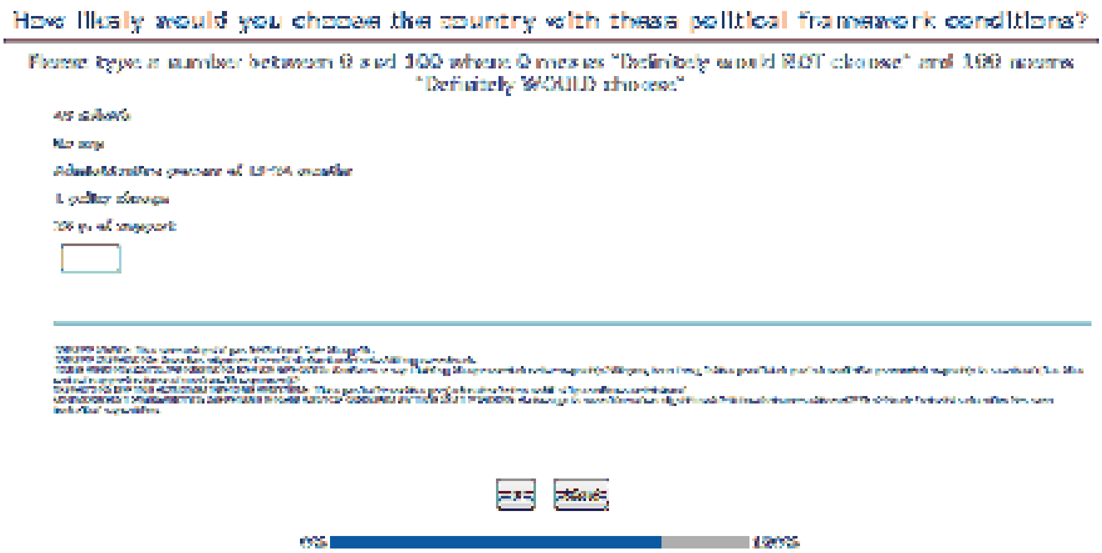

How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"
Administrative process of 1-2 months
No cap
45 ct/kWh
25 y. of support
0 policy changes
<<
Next
0%
100%

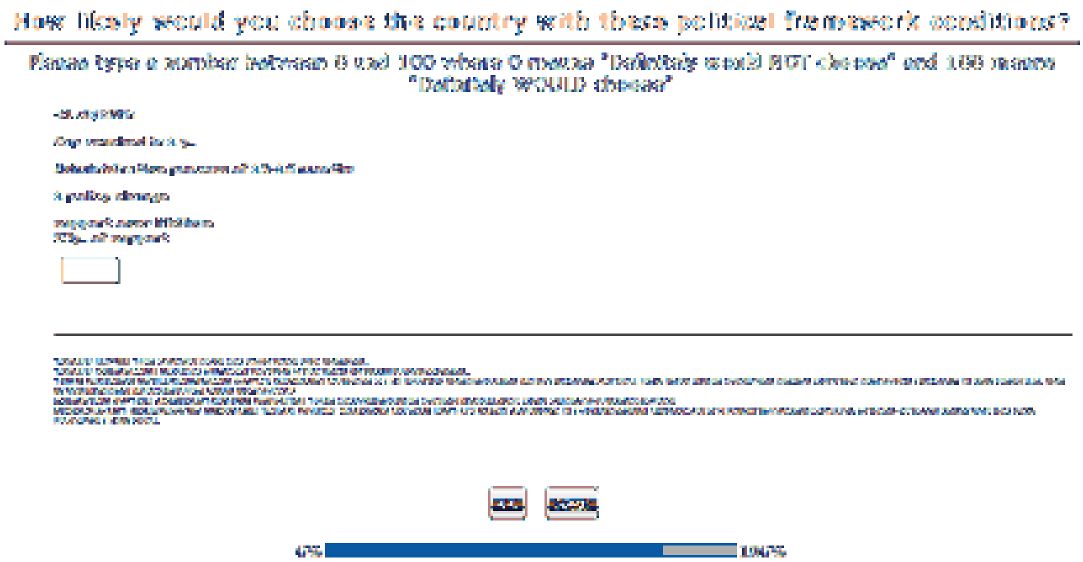

How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"
Administrative process of 19-24 months
Cap reached in 1 y.
31 ct/kWh
25 y. of support
0 policy changes
<<
Next
0%
100%


How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"
Administrative process of 1-2 months
No cap
31 ct/kWh
15 y. of support
3 policy changes
<<
Next
0%
100%


How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"
Administrative process of 19-24 months
Cap reached in 1 y.
45 ct/kWh
25 y. of support
0 policy changes
<<
Next
0%
100%


How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"


How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"
No cap
1 policy change


How likely would you choose the country with these political framework conditions?
Please type a number between 0 and 100 where 0 means "Definitely would NOT choose" and 100 means "Definitely WOULD choose"

You are almost done, there are just three more pages left!

What is the importance of the following factors in the choice of a country for solar projects?

	not important	somewhat important	important	very important	extremely important
Solar radiation					
Market demand					
Market potential					
Local production of solar modules					
Available grid capacity					
Gap to political solar target					
Level and duration of the feed-in tariff					
Guaranteed law-enforcement					
Solar policy stability					
Duration of the administrative process					
Knowledge of the local language					
Local contacts					
Other, please specify [ ]					
Other, please specify [ ]					

<< Next

0% 100%

What is your [illegible]

- Project developer not vertically integrated (planning but not building the solar plants)
- Project developer vertically integrated
- Investor, please specify [ ]
- Other, please specify [ ]

In which country is your company's headquarters located?
(Multiple answers possible)

- Germany
- Spain
- Italy
- Greece
- Portugal
- France
- Switzerland
- Other, please specify

[illegible]
(Multiple answers possible)

- Choice of the plant's location
- Feasibility study
- Permitting process
- Grid-interconnection agreement
- Site acquisition
- Fundraising for the solar plant realization
- Construction of the plant
- Plant operation
- Plant maintenance
- Others, please specify

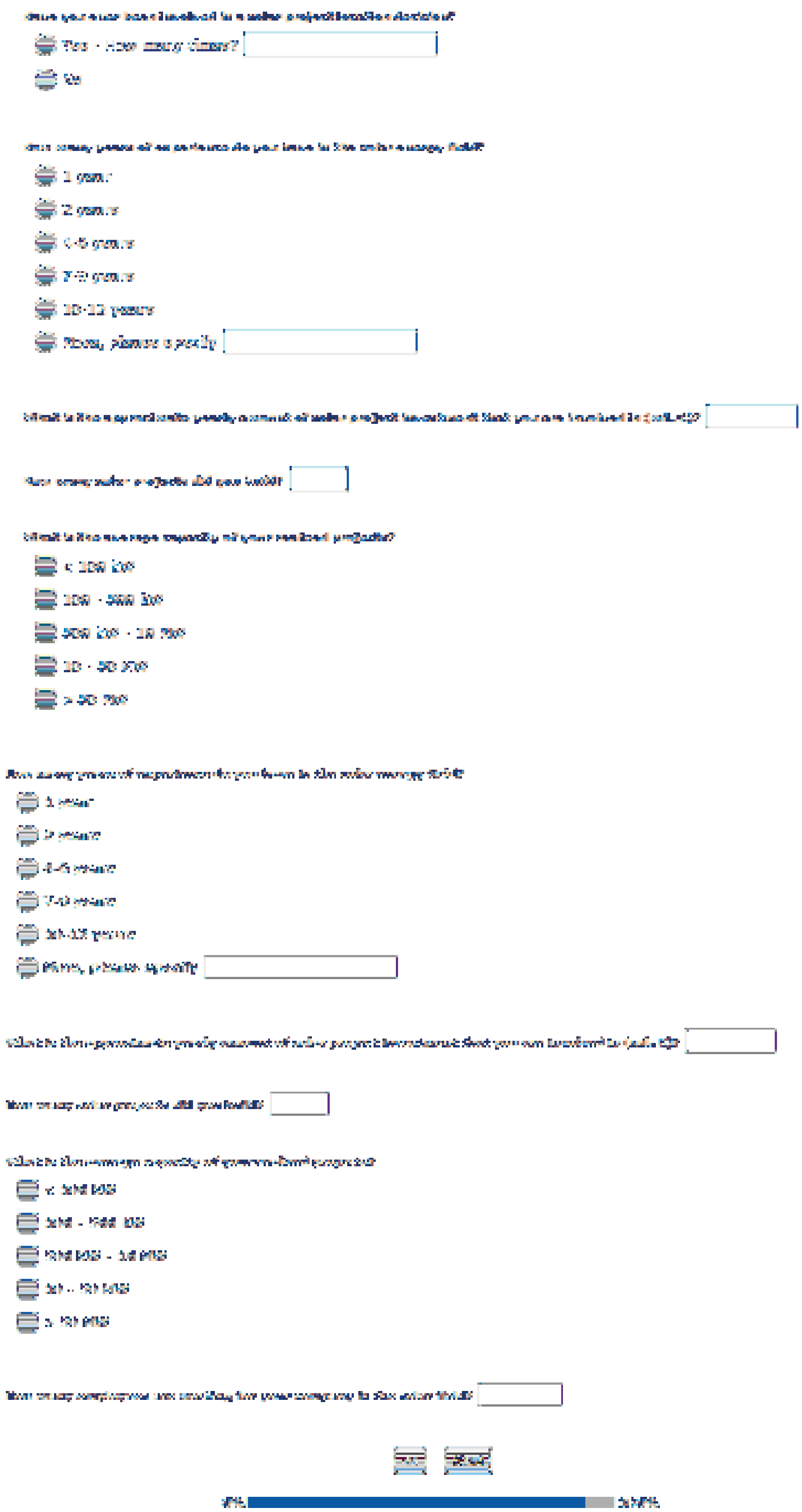
[illegible]
(Multiple answers possible)

- Germany
- Spain
- Italy
- Greece
- Portugal
- France
- Switzerland
- Others, please specify

[illegible]
(Multiple answers possible)

- Germany
- Spain
- Italy
- Greece
- Portugal
- France
- Switzerland
- Others, please specify

0% 100%



Yes - How many times?
No
1 year
2 years
4-6 years
7-9 years
10-12 years
More, please specify
< 100 kW
100 - 500 kW
500 kW - 10 MW
10 - 50 MW
> 50 MW
1 year
2 years
4-6 years
7-9 years
10-12 years
More, please specify
< 100 kW
100 - 500 kW
500 kW - 10 MW
10 - 50 MW
> 50 MW

If you wish to be informed about the results of the survey, please enter your e-mail address:

E-mail:

Please enter further comments or questions below:

<< Next

0% 100%

Thank you very much for your participation!

Institute for Economy and the Environment

University of St.Gallen

DISTRES

<< Next

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4 Analyzing Policy Support Instruments and Regulatory Risk Factors for Wind Energy Deployment – A Developers' Perspective[11]

Sonja Lüthi and Thomas Präßler (2010)

Abstract

Making a successful transition to a renewable energy system is high on the policy agenda in many countries, and a promising fuel source for a low-carbon energy future is wind energy. By providing an attractive policy framework, policy-makers have the potential to attract wind energy development in their countries. This paper argues that apart from the level of the financial support, both the risks stemming from the regulatory environment (legal security, administrative process and grid access) and the ability to finance projects play a critical role in determining the attractiveness of the development environment. Using conjoint analysis, this paper provides insights into how European and U.S. wind energy project developers trade off these different aspects and to what extent the attractiveness of a certain policy framework increases with the introduction of specific measures. The analysis shows that while developers' preferences are very similar in the studied regions, which policy measures are most valuable depends on the specific environment. In some Southeastern European countries, a reduction of administrative process duration may yield the highest utility gains, whereas, in the U.S., improvements in grid access regulation and an increase in remuneration levels may be more effective.

Keywords: Renewable energy policy; Wind energy development; Conjoint analysis

[11] Chapter 4 is referred to as study 3 in this doctoral thesis.
This chapter is the revised version of an article submitted to Energy Policy in August 2010.

4.1 Introduction

Although the overall share of renewable energy in global electric power supply is still low, there is significant growth in some subsectors. In 2008, global power generation investment in renewables exceeded investment in fossil-fueled technologies for the first time (Hohler, Greenwood et al., 2009). Wind energy is the most prominent renewable technology: in 2009, it accounted for 64% in the EU and 90% in the U.S. of all new renewable generating capacity and for 39% of all new EU and EU electric generation capacity (Bloem, Szabo et al., 2010; EWEA, 2010a; Wiser and Bolinger, 2010).

Governments around the world are increasingly adopting policies to promote the production of renewable energy (Rickerson, Sawin et al., 2007; REN21, 2009). Support policy currently plays the most important role in the deployment of wind energy (Bird, Bolinger et al., 2005; Menz and Vachon, 2006; Meyer, 2007; Wiser and Bolinger, 2010). A broad strand of literature assesses which promotion schemes have delivered adequate results. Some researchers approach the question from a societal perspective and focus on the primary support instrument. Held, Ragwitz et al. (2006), for instance, came to the conclusion that a well-designed feed-in tariff (FIT) system ensures the fastest deployment of renewable energy technologies at low cost to society and is superior to market based instruments.

This is not to say that FIT schemes are a bulletproof recipe for success. Many studies pointed out, early on, that attractiveness of a policy scheme is not an inherent property of any particular instrument; but rather it is the specific design and the implementation that determines success (e.g., Dinica, 2003; Sawin, 2004; Couture and Gagnon, 2010). Del Rio and Gual (2007) state that the Spanish FIT system has been successful in the deployment of wind energy, but stress that this success depends on several factors, of which only few are directly related to the support scheme. Mendonça (2007) and Couture and Gagnon (2010) conceptually show that there is a variety of different FIT schemes that can have quite different effects on investor risk and renewable energy deployment. There are also empirical examples where the deployment of some renewable energy technologies (RET) has been less successful despite the presence of FITs. Dinica (2009) explores several reasons why the diffusion of biomass power in Spain has been less successful despite FIT support. Nadaï (2007) shows that France's attempt to adopt parts of Germany's wind power FIT scheme could not produce equivalent results, because many other factors, in this case mainly institutional factors, played a role in wind power development.

Hence, for the analysis of RET diffusion, it is crucial to look beyond the primary support instrument and also scrutinize implementation and risks factors. Many scientific studies and industry reports mention regulatory barriers that represent risks for project developers. These barriers include administrative hurdles like strong environmental regulations and long, bureaucratic and nontransparent authorization and permitting procedures; obstacles to grid access like insufficient grid capacity, long, nontransparent, costly procedures for grid connection; and support policy instability with sudden policy changes and stop-and-go situations (among others Beck, Martinot et al., 2004; Haas, Eichhammer et al., 2004; OECD/IEA, 2008; Sovacool, 2009b; EWEA, 2010b). Thus, it is not necessarily the type of support instrument that influences investor behavior and hence deployment patterns, but rather its specific risk/profitability characteristics (Dinica, 2006). To better understand the impact of policy measures on the investor community, she proposes and conceptualizes an investor-oriented analysis model to analyze the diffusion potential of support systems for RETs.

On that note, project developers are a valuable study target group. They are important market players as they effectively link the regulatory environment and financial incentives to the available investment funds in the market. On the one hand, developers observe the national, regional and local regulatory environment and financial incentives in place and react to them. On the other hand, their activities cater to the needs of the investor community to eventually sell the developed projects. In academic research, a developers' and investors' perspective was adopted by academics as early as the nineties, for example by Mitchell (1994), Langniss (1996) and Wiser et al. (1997). Langniss (1996) categorized different types of investors and recognized that the type of support and taxation scheme has implications on which type of investor will be attracted. Wiser et al. (1997) identify perceived resource and technology risks and high support policy risk as the main hurdles that renewables project developers face in obtaining financing. The contributions of Dinica (2003; 2006) showed how policy language needs to be translated into investor language with focus on the interplay of profitability and risk of projects. Bürer and Wüstenhagen (2009) emphasize that the understanding of investor perceptions, in turn, may provide policy-makers with the opportunity to leverage private investment to reach renewable energy targets.

Using mostly case studies and conceptual analyses, all these studies provide valuable insights for understanding the drivers of development and diffusion of new RET capacity. At the same time, researchers' perception of risks and benefits in a given support system may not coincide with developers' perception and thus empirical research including investors/developers has been encouraged (Dinica 2006). Additionally, there is less detailed knowledge of which measures can actually alleviate risks such as planning risks, grid regulations and legal security and how these measures relate to each other in developers' perception.

This empirical study on the policy preferences of wind energy project developers therefore largely builds on the findings of existing literature and intends to add to them in four ways: It employs a novel research methodology, it provides an empirical dataset of wind developers' preferences, it makes the impact of various policy factors on developers' preferences measureable, and it gives some indication of how these findings differ for different regions in the EU and the U.S..

The employed methodology, conjoint analysis, is widely used in marketing research and has recently gained some popularity in the energy and resource economics literature. This method allows the partitioning of decision-making processes into underlying respondent preferences for specific stimuli (e.g., financial and regulatory measures) and delivers real-time information about how specific measures affect developer's preferences and thus tomorrow's installed energy capacities. As a result, it allows quantifying how much value specific measures provide to developers given a specific policy environment. The paper suggests that conjoint analysis could be a helpful scenario tool for estimating potential effects of specific policy measures on project developers' investment behavior.

The paper is structured as follows. The next section specifies the method by introducing conjoint analysis and explaining the experimental design as well as the data analysis approach. Section three describes the study sample. Section four presents and discusses the results. It includes a break down of developers' preferences for the studied attributes and levels, simulations of the effects of policy measures on developers' preferences in specific investment environments and an analysis of preference differences between different subgroups of project developers. Finally, section five concludes by highlighting main findings, outlining policy recommendations, indicating the limitations of this study and making suggestions for further research.

4.2 Methodological Approach and Experimental Design

4.2.1 Conjoint Analysis

Conjoint analysis methods are based on work done in the sixties by the mathematical psychologists and statisticians Luce and Turkey (1964) and were introduced into marketing research in the early 1970s (Green and Srinivasan, 1990; Orme, 2007b). The key characteristic of conjoint analysis is that respondents evaluate product profiles composed of multiple conjoined elements (attributes). The main objective is to mimic real decision making processes as closely as possible. The respondents' evaluation of the combined sets of attributes (the product scenarios) makes it possible to calculate the preference scores that they implicitly assign to individual components of the product.

Conjoint analysis is based on Discrete Choice Theory (Ben-Akiva and Lerman, 1985; Train, 2009). Microeconomic consumer theory and utility maximization provide the first foundation to discrete choice theory. However, it is not possible to completely describe any option's utility in terms of its attributes; there will always be some unknown or intangible characteristics which may provide additional utility. Random Utility Theory (Mansky, 1977) is thus the second foundation of discrete choice theory and the direct utility function of a person can be broken down into observable (deterministic) and unobservable (stochastic) parts.

The utility of a policy framework can be described as:

$$U = \sum_{i=1}^{n} u_i + e \qquad (1)$$

where U describes the utility of the chosen policy framework, n the number of policy attributes, u_i the part-worth utilities of the attributes i and e the unknown or intangible characteristic.

The probability that a project developer k chooses the policy framework j from choice set C_t is given by the following (adapted from Ben-Akiva and Lerman (1985)):

$$P_{kj} = \Pr(U_{kj} \geq U_{km}; \forall j \neq m; j, m \in C_k) \qquad (2)$$

where P_{kj} describes the probability that a project developer k chooses the policy framework j, U is the utility of the policy framework alternatives, j stands for the chosen policy framework alternative, m represents all other alternatives and C_k the choice set available to the project developer k.

The conjoint analysis technique applied in this study is adaptive choice based conjoint analysis (ACBC). ACBC captures more information at the individual level than traditional, non-adaptive surveys and may be used even with small samples of about 60 participants (Shepherd and Zacharakis, 1999; Orme, 2010a). ACBC prevents respondents from focusing on paramount attributes and neglecting others as it recognizes such attribute levels and then focuses in subsequent questions on the remaining ones. Hence, the questions generated during the course of the survey are based on factors that are identified as being relevant to the survey respondent (Sawtooth Software, 2007). Additionally, the customized approach decreases the time required to complete the survey and prevents respondents from potential information overload or confusion (Sawtooth Software, 2007).

4.2.2 Selection of attributes – investigating the drivers for project development decisions

In this paper, we assume that renewable energy project developers choose their projects' locations by looking for the bundle of attributes that provides the highest utility. In this choice among alternatives, there is an inevitable trade-off between the different attributes, and any attribute change influences the attractiveness of the respective country for the project developer. A higher level of support, for example, increases the utility and thus the attractiveness of a country, whereas longer administrative duration decreases the utility.

In order to determine the relevant drivers for the development decision to investigate in this study, we have a) screened existing literature that cover drivers of wind power development and b) conducted a qualitative pre-study with experts in the field. As mentioned above, studies have shown that developers do not exclusively focus on the level and type of financial support when making the development and siting decision. Risks that are inherent to the development process and lead to uncertainty and higher costs are also decisive. Nontransparent, lengthy processes for acquiring building consent and grid connection permits can be major barriers to the development of new wind power plants and their integration into the energy markets (Johnston, Kavali et al., 2008; EWEA, 2010b).

Table 4.1 shows an overview of the most important factors influencing the decision making process of wind power developers.

Table 4.1: Overview of factors influencing the development decision, not exhaustive. Shaded area shows focus of this study.

Factors	Controlling entity	Use in study
Policy factors		
Risk factors		
• Administrative approval duration / complexity / transparency • Grid access regulation (e.g., access guarantee, priority dispatch / connection costs) • Legal security (contract enforceability) • Renewable energy policy stability	Policy makers	Included; explaining variable Included; explaining variable Included; explaining variable Not included
Return factors		
• Level of production based support (e.g., feed-in tariff, tradable green certificates, production tax credit) • Duration of production based support • Level of investment based support (e.g., cash grants, investment tax credit) • Level of financing support (e.g., soft loans)	Policy makers	Indirectly included; "total remuneration" as explaining variable Defined in survey as 20 year Included; explaining variable Included; explaining variable
Organizational and behavioral factors • Type and size of developer company • Experience with wind development • Knowledge of and attitudes towards energy policy, financial markets and market environment • Local / national investment culture • Personal factors (e.g. risk propensity, personal networks)	Mostly within sphere of control of developer, some beyond control	No explaining variable but discrimination in results No explaining variable but discrimination in results Not included Not included Not included
Market based factors • Electricity demand • Competition • Access to local partners and trained employees • Price of electricity • Infrastructure • Currency risk	Mostly driven by markets, only indirectly controlled by policy makers, however not specific to wind energy	Not included Not included Not included Indirectly included; "total remuneration" as explaining variable Not included Not included
Wind resource quality	None	Defined in survey as "high wind quality location that yields an average capacity factor of ~25% (~2200 full load hours)".

The goal of the study is to measure the impact that policy settings and regulations have on developer decision making and to assess what policy-makers can do to increase the attractiveness of the policy support system for wind power developers. We therefore focus on factors that can be influenced by policy-makers. These include all aspects which involve some sort of governmental action, or at least the possibility of such (Butler and Joaquin, 1998).

Besides these regulatory factors, there are many organizational and behavioral factors that influence the choices of project developers. These include, for instance, expertise, fast and efficient development processes at the developer's end, procurement of turbines, choosing turbines that best match the wind regime, etc. These factors are not included as explaining variables in the study because they are competencies incumbent on the developers themselves. Also, factors that are largely beyond the control of wind power policy-makers and developers are excluded as explaining variables of the study. These are mostly market based factors such as access to local partners and trained employees, competition levels, currency risks or existing infrastructure.

Analogously, the quality of the wind resource was excluded as an explaining variable, but expectations regarding the quality of the wind resource were homogenized among respondents[12].

To verify that we included the most relevant aspects (attributes) in the conjoint analysis and to determine which parameter specifications (levels) were most appropriate for each attribute, we conducted 24 interviews with wind power experts in Europe and the U.S. The sample included small, medium and large wind energy developers, utilities with their own development activities, development banks, policy-makers and researchers in the field of wind energy policy. The interviews were semi-structured, following interview guidelines.

Based on the expert interviews, six attributes and relevant levels were chosen to reflect the current market conditions in the studied regions and included in the ACBC experiment (cf. Table 4.2). The identified attributes included in the conjoint analysis are both relevant for the development decision and independent from each other (i.e., the utility of the attribute and the perceived utility of a level should not interact with other attributes) (Backhaus, Erichson et al., 2006).

"Administrative process duration": Obtaining all permits required to build the wind energy plant is key to a developer's business. The efficiency of the administration process depends, among other things, on its transparency, on the reliability of permit approvals and on the total number of authorities involved (Strom, 2010). It is impossible to assess all these aspects individually in a conjoint analysis, but they are combined in the total average duration to get final authorization for a project.

"Legal security": Legal security includes overall legal stability, a country's track record as to legal conduct, corruption levels, enforceability of contracts and reliability of business partners.

[12] In order to control expectations about the total number of electricity produced, a disclaimer prior to the survey instructed respondents: "For all of the following questions please assume you want to develop a generic onshore wind power project of 10 MW at a high quality wind location that yields an average capacity factor of ~25% (~2200 full load hours)." This disclaimer brings ingoing assumptions about electricity production on one level (2200h*10 MW=22.000 MWh).

“Grid access”: Grid access is a complex issue that comprises multiple aspects: 1) the capacity of the grid to deal with the quantity and quality of wind electricity, 2) the availability/proximity of access points, 3) the national/regional long term strategy for grid expansion, 4) regulations regarding access guarantee and cost sharing between grid operators and developers, and 5) regulations regarding the dispatch of wind electricity. To concentrate on the issues that can both be directly influenced by policy-makers and have an immediate impact on developers, we chose levels to reflect access guarantee and dispatch regulations.

“Total remuneration”: The total remuneration describes the total production-based income per kWh. This includes electricity sales (power purchase agreement), feed-in tariff, production tax credit, tradable certificates, etc. From a project profitability point of view, the income source is less decisive, as long as the sum of all operating income sources is sufficiently high and sufficiently stable. We therefore framed this attribute to comprise all sources of income on a secure, 20 year basis.

“Credit financing”: Many wind energy plants are debt financed, especially in Europe. In the aftermath of the credit crisis, many developers have difficulties in securing debt financing at attractive prices. Government-backed soft loans are an effective way of providing funds for wind energy development. In Germany, for instance, the “Renewable Energy Program” of the KfW bank is involved in almost 2/3 of all installed wind energy plants (Bickel, Kelm et al., 2009).

“Investment cash grants”: Apart from production-based support, policy-makers can opt to subsidize part of the initial upfront investment of a project. Especially in the U.S., this is a widely used instrument.

To avoid unrealistic return level combinations, three prohibitions were included, i.e., the highest and second highest “Remuneration” and “Cash grants” levels will not show up together in any scenario[13].

[13] (1) 14 € ct/kWh// 19 $ ct/kWh and 30%; (2) 14 €ct/kWh// 19 $ct/kWh and 20%; (3) 11 €ct/kWh// 15 $ct/kWh and 30%.

Table 4.2: Attributes and attribute levels used in the ACBC experiment

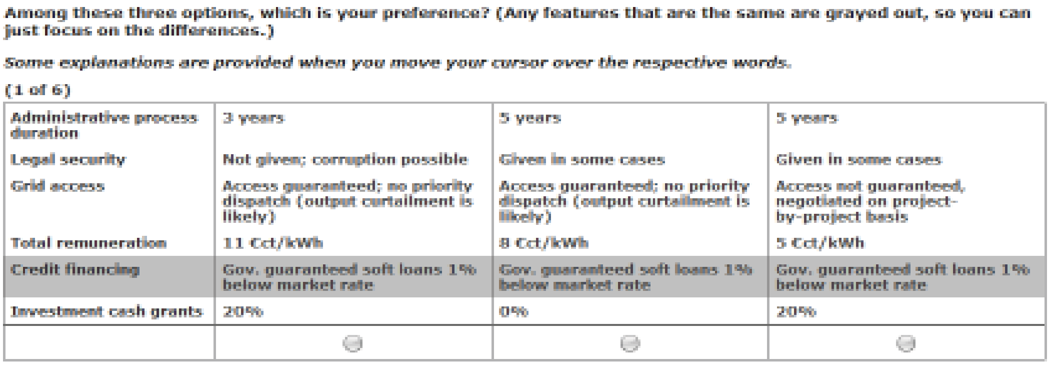
Attributes	Description provided in survey	Attribute levels used in survey
Administrative process duration	Total time to obtain all required permits from first application to final authorization of plant. Not included: time for technical site evaluation, PPA negotiations, construction, etc.	1 year 3 years 5 years 7 years
Legal security	Confidence in contract enforcement and predictability of legal decisions	Not given, corruption possible Given in some cases Given in most cases Given in all cases
Grid access	Arrangements in place to regulate access to transmission and distribution systems.	Access not guaranteed, negotiated on project-by-project basis; Access guaranteed; no priority dispatch (output curtailment likely) Access guaranteed, mostly priority dispatch (minor output curtailment possible); Access guaranteed, priority dispatch (no output curtailment)
Total remuneration	Sum of all income streams related to electricity sales (feed-in tariff, power purchase agreement, tax credit, premium, certificate, etc.) over 20 years.	5 € ct/kWh // 7 $ ct/kWh 8 € ct/kWh // 11 $ ct/kWh 11 € ct/kWh // 15 $ ct/kWh 14 € ct/kWh // 19 $ ct/kWh
Credit financing		No support; Gov. guaranteed soft loans 0.5% below market rate; Gov. guaranteed soft loans 1% below market rate; Gov. guaranteed soft loans 1.5% below market rate;
Investment cash grants	Non-reimbursable cash payments as percentage of total investment costs.	0% 10% 20% 30%

4.2.3 Questionnaire Design

The online survey (http://www.windinvestment.ch) consisted of two parts: 1) the conjoint analysis experiment to analyze the part-worth utilities and importance of different policy attributes, and 2) background questions about the participants and the companies at which they were employed. It was designed with Sawtooth Inc. (SSI Web), which is a standard software solution for the design and analysis of conjoint analysis experiments (Sawtooth Software, 2008).

The ACBC experiment started with screening questions presenting four policy-framework scenarios at a time. Each respondent was asked to indicate whether he/she would consider developing a wind energy project under the indicated conditions. The alternative scenarios were constructed using a factorial random design with an orthogonal set of attributes. This section recognized if respondents used cutoff rules focusing just on a few attributes instead of evaluating the scenarios as a whole. If so, he/she could indicate critical attribute levels as a “must have” (i.e., as an absolute requirement) or as “unacceptable”. All further scenarios shown then satisfied those requirements.

In the subsequent choice tasks section, the respondent selected the preferred scenario out of three scenarios previously marked attractive for investment (cf. Figure 4.1). The chosen scenarios of each triple then showed up again in subsequent choice tasks until the most preferred scenario was identified.


Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(1 of 6)

Administrative process duration	3 years	5 years	5 years
Legal security	Not given; corruption possible	Given in some cases	Given in some cases
Grid access	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access not guaranteed, negotiated on project-by-project basis
Total remuneration	11 €ct/kWh	8 €ct/kWh	5 €ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1% below market rate
Investment cash grants	20%	0%	20%

Figure 4.1: Screenshot of choice section of ACBC survey

The conjoint section was concluded by a so-called holdout task. Holdout tasks are not used to estimate part-worth utilities but to assess the quality and performance of the model used for the utility estimations (see section 4.4). If the responses to hold-out questions can be predicted accurately using estimated part-worth utilities, it lends greater credibility to the model.

4.2.4 Data Analysis Approach

The 4749 choices of the 119 respondents (39.9 tasks per person) were used to assess the value of the different attributes and levels. The estimations of the part-worth utilities as well as the preference simulations were conducted using Sawtooth Software, Inc. programs (SSI Web and SMRT). In addition, SPSS 18 was used to do further statistical analysis.

Part-worth utilities measure the contribution of attribute levels to the overall utility, i.e., the influence of a change of the respective variable on the developer's likelihood to develop a specific project. The average part-worth utilities are calculated from the individual part-worth utilities of each respondent, using the hierarchical Bayes (HB) estimation model (Rossi and Allenby, 2003; Orme, 2007a) which has become the standard estimation method for conjoint analysis (Lenk, DeSarbo et al., 1996; Rossi and Allenby, 2003; Netzer, Toubia et al., 2008). Individual utilities allow assessing heterogeneity among customer segments, which is more difficult with traditional conjoint approaches based on aggregated preferences measures (e.g., standard multinominal logit (MNL) (McFadden, 1986)).

HB assumes that the respondent answers choice tasks according to a MNL model. MNL considers the probability of the specific alternative being chosen (P_{kl}) related to the proportion of the total utility for that concept relative to the total utility for all the concepts according to this formula (adapted from Howell (2009)):

$$P_{kj} = \frac{e^{U(j)}}{\sum_{l=1}^{m} e^{U(l)}} \qquad (3)$$

where P_{kj} is the probability that the developer chooses policy framework j, m the number of alternatives and l the policy framework alternative.

The HB model consists of two levels. At the upper level, respondents are considered as members of a population of similar individuals (Orme, 2010b). Their part-worth utilities are assumed to have a multivariate normal distribution described by a vector of means and a matrix of variances and covariances. At the lower level, each individual's part-worth utilities are calculated by a linear regression model according to the respondent's choices within the conjoint analysis experiment. Discrepancies between actual and predicted choices are assumed to be distributed normally and independently of one another. With several thousands of iterations (for this study, 40,000 iterations were done), each respondent's utilities are adjusted so that they reflect the optimal mix of the individual respondent choices and the sample averages (Howell, 2009).

Part-worth utilities are interval data and scaled to an arbitrary additive constant within each attribute (Orme, 2010a). It is thus not possible to compare utility values between attributes. Zero-centered differentials (diffs) part-worth utilities are scaled to sum to zero within each attribute, and the sum of the average differences between best and worst levels across all attributes is equal to the number of attributes times 100 (Orme, 2010b). This makes it possible to compare the differences between the attribute levels**.**

The importance scores of each attribute are calculated taking the range of the attributes' utility values, i.e., the highest and the lowest part-worth utility of each attribute. A bigger range signifies a higher importance (Backhaus, Erichson et al., 2006). The relative importance of each attribute is calculated using the formula (adapted from Clark-Murphy and Soutar (2004)):

$$RI_l[\%] = \frac{(MaxU - MinU)i}{\sum (Max - Min)i} x100 \qquad (4)$$

where RI_i is the relative importance of attribute i; $MaxU$ the maximum utility of attribute i; and $MinU$ the minimum utility of attribute i.

The counts analysis provides insights about the “unacceptable” or “must have” levels and indicates how often specific levels have been chosen in the winning scenario of the choice section.

Preference simulations allow gauging the impact on developers’ preferences of certain attribute level changes within specific policy environments (i.e., sets of attribute levels). The simulations estimate the probability that project developers would develop a project in different policy frameworks by summing scaled utilities and applying the following transformation (adapted from Orme, 2010b):

$$p[\%] = \frac{e^{u}}{1+e^{u}} x100 \qquad (5)$$

where p is the probability of investment, e is the constant e and u is the utility of the policy framework in question. Values created by the preference simulations indicate ratio scaled relative preferences.

4.3 Data Collection and Sample

The wind energy project developers included in this study are experts who work or have worked for companies engaged in the project development business. These include:

- Highly specialized, typically small firms whose exclusive business focus is the development of renewable energy projects. Due to the lack of capital or financing, they often sell the project during or after the development process.
- Vertically integrated, typically larger firms, who plan, build, own and operate renewable energy projects.

In total, 1260 wind energy developers active in the U.S. and Europe were contacted individually between April and July 2010. The contact information of the target sample was gathered via personal contacts, wind energy conferences[14], profiles on professional network websites[15], collaboration with wind energy associations[16] and publicly available contact information (mainly member directories of associations such

[14] EWEC 2010, Warsaw, April 20-23, 2010 and Wind Energy Forum 2010, Davis, May 10, 2010

[15] www.xing.de; www.linkedin.com

[16] Bundersverband für Windenergie and the Finnish wind energy association supported the study with direct mailing to their members; the American Wind Energy Association and IG Windkraft Österreich published the survey link in member newsletters or websites, respectively).

as AWEA and RENUK). Where email addresses were available, a reminder was sent after 4 weeks.

The response funnel is shown in Figure 4.2. With 102 complete data sets, the final conversion rate was 8.1%. For the regional analysis (section 4.4), 108 respondents could be used, as they completed the conjoint analysis section and indicated in which countries they were active. The choice data of 119 respondents could be used for the preference calculations as 17 respondents quit the survey only during the background questions.

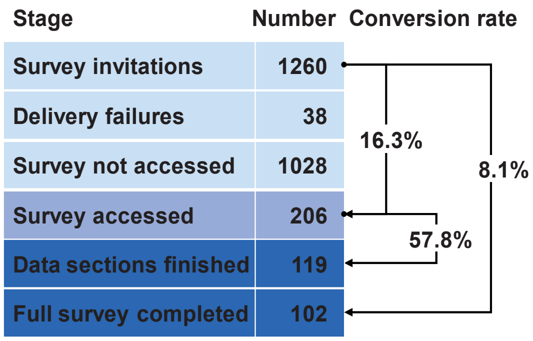


Figure 4.2: Response funnel

Table 4.3 summarizes the sample characteristics. The majority of respondents have 3 or more years of experience with wind energy development. Most developer companies are independent developer or independent power producer companies, are engaged in multiple parts of the development, and are of small to medium size with annual development of up to 100 MW wind energy installation.

Table 4.4 shows the regional distribution. While many companies have their headquarters in Germany or the U.S., most are active in multiple European and U.S. markets. Actual development activities are spread over the U.S. and 25 countries throughout Europe.

Table 4.3: Descriptive statistics of wind energy project developer in our sample

Characteristic	Levels	Share
Developer type (n=105, multiple choices possible)	Independent developer	70%
	Independent power producer	28%
	Utility	8%
	Other	18%
Investment phase (n=105, multiple choices possible)	Greenfield development	74%
	Early maturity	67%
	Late stage, financing	54%
	Operations	55%
	Construction	39%
	Other	10%
Respondent's experience with wind development (n=105)	< 2 years	38%
	3 – 5 years	23%
	6 – 12 years	29%
	> 12 years	8%
Company experience with wind development (n=105)	< 2 years	20%
	3 – 5 years	13%
	6 – 12 years	26%
	> 12 years	33%
Average project size (n=95)	< 6 MW	9%
	6 – 15 MW	24%
	16 – 30 MW	31%
	31 – 100 MW	28%
	> 100 MW	7%
Cumulative investments over last 3 years (n=73)	< 15 mio €	38%
	16 – 100 mio €	18%
	101 – 300 mio €	16%
	301 – 1000 mio €	15%
	> 1000 mio €	12%

Table 4.4: Geographic distribution of development activities in our sample

County	**Development activities (n=105) Count / (Percentage)** (multiple choices possible)	**Headquarter (n=105) Count / (Percentage)**
Northwest Europe	**162**	**60 / (57%)**
Germany	47 / (45%)	36 / (34%)
France	38 / (36%)	2 / (2%)
Great Britain	31 / (30%)	8 / (8%)
Sweden	19 / (18%)	2 / (2%)
Denmark	10 / (10%)	5 / (5%)
Austria	6 / (6%)	1 / (1%)
Finland	3 / (3%)	2 / (2%)
Other (Ireland, Netherlands, Belgium, Norway)	8 / (8%)	4 / (4%)
Southeast Europe	**194**	**23 / (22%)**
Poland	40 / (38%)	2 / (2%)
Italy	33 / (31%)	4 / (4%)
Romania	26 / (25%)	0 / (0%)
Spain	25 / (24%)	7 / (7%)
Bulgaria	25 / (24%)	2 / (2%)
Greece	14 / (13%)	1 / (1%)
Turkey	12 / (11%)	0 / (0%)
Croatia	7 / (7%)	0 / (0%)
Portugal	4 / (4%)	3 / (3%)
Slowenia	3 / (3%)	0 / (0%)
Other (Hungary, Serbia, Slovakia,)	5 / (5%)	4 / (4 %)
U.S.	**40 / (38%)**	**22 / (21%)**

4.4 Results and Discussion

The root likelihood (RLH) indicates the goodness of fit of the HB model. In our model, it amounts to 0.751 indicating a good fit. The RLH for each individual is the geometric mean of the probabilities of the different choices made by the individual. The probabilities are calculated using the posterior means of an individual's part-worth utilities in the MNL model (Wonder, Wilhelm et al., 2008). The RLH of the model is the arithmetic average of all the individual RLH values (the upper level normal distribution is thus ignored). The RLH is between 1.0 (best possible value) and the probability of the different choices in the average task, i.e., our model with three choices has a minimum RLH of .33.

The analysis of the responses to the holdout task provides an indication of how well the utility values estimated from the ACBC model (indirectly stated preferences) were able to predict the respondent's actual holdout choices (directly stated preferences).

The share of preference results are displayed in Table 4.5. The simulated share of preference values were within 6% of the actual preferences indicated in the holdout data.

Table 4.5: Holdout task: comparison of directly stated preference (SP) and model data

	Option 1 (SP/ model)	**Option 2 (SP/ model)**	**Option 3 (SP/ model)**
EU	76.71%/ 76.42%	21.92%/ 23.26%	0.01%/ 0.32%
U.S.	70.00 %/ 75.16%	30.00%/ 23.94%	0%/ 0.90%
Total	74.76%/ 75.74%	24.27%/ 23.87%	0.01%/ 0.39%

4.4.1 Importance Scores

Figure 4.3 presents the means and standard deviations of the relative importance scores of the attributes examined in this study. “Legal security” (28.2%) and “Remuneration” (27.4%) have the highest importance scores, followed by “Administrative process duration” (17.1%). “Investment cash grants” (11.0%), “Grid access” (10.1%) and “Credit financing” (6.3%) are of lower importance.

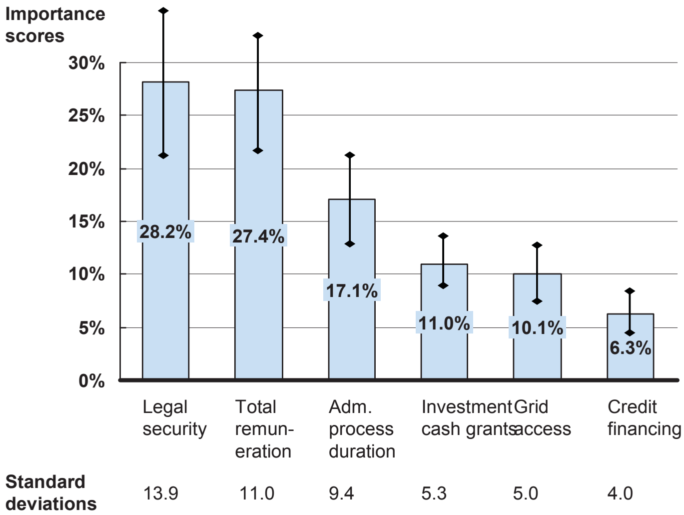


Figure 4.3: Importance scores and standard deviations

Importance scores can be best interpreted as the degree to which the difference in utility between the best and the worst level of a given attribute impact the overall utility of the respondents. They are calculated based on attribute level part-worth utilities (see formula 4), i.e., if the partial utility scores of a given attribute show a large discrepancy between the lowest and highest level, this attribute is important for determining the overall utility and thus its importance score is high. As a result, the importance scores are slightly influenced by the survey design (Wittink, Vriens et al., 1992; Orme, 2010b), i.e., by the number and the range of attribute levels. More specifically, this means that if the levels of, e.g., the attribute "Administrative process duration" were designed to show extreme values – for instance, ranging from 3 months to 15 years – it would result in a slightly higher importance score than in the current study because such high discrepancies in development duration would make a big difference to developers. To include an adequate choice of attribute levels, they were selected with respect to the actual market conditions in the analyzed countries and verified by the expert interviews and own research on prevailing policy settings. Using real-world parameterization of the attribute levels ensures that the results are meaningful for both practitioners and policy-makers. As a result, some attributes show pronounced ranges in attribute levels (in particular, "Legal security" and "Remuneration"), reflecting the current differences of policy and regulatory situations.

The results indicate that factors representing sources of risks to the development process of wind energy projects such as legal security and the administrative process duration are very important to developers. As expected, "Remuneration" is an important attribute, but it is worth noting that it is not dominating. Many policy discussions tend to place a very strong focus on the level of FIT or credits, but this analysis suggests that the majority of total utility is derived from other aspects. Remuneration during the operating phase of the project is more important than upfront investment support measures (i.e., investment cash grants and credit financing). This does not mean that these measures do not have value for wind developers, but the lower importance scores of "Credit financing" and "Cash grants" reflect their lower impact on the internal rate of return (IRR) of a wind power project. Using a simple discounted cash flow (DCF) model, we estimate that the impact of a one-level increase in "Remuneration" on the internal rate of return (IRR) of a wind energy project is three to four times higher than a one-level increase in "Cash grants" and almost ten times higher than for a one-level increase in the attribute "Credit financing". These considerations are well reflected in the importance score results which indicate that respondents adopt rational behavior when stating their preferences.

4.4.2 Unacceptable and most preferred attribute levels

In the screening section, 55% of the respondents indicated that they would not develop a wind energy project in a country where legal security is "Not given, corruption possible" (Figure 4.4). For 31% of the respondents, the total remuneration needs to be higher than "5 €ct (7$ct)/kWh" and 26% see a "7 years" administrative process duration as a knock-out criterion. This shows that many project developers have critical minimum requirements and that they use, in the case of very high risks (e.g., very low “Legal security”) or low remuneration, non-compensatory decision-making rules when evaluating opportunities.

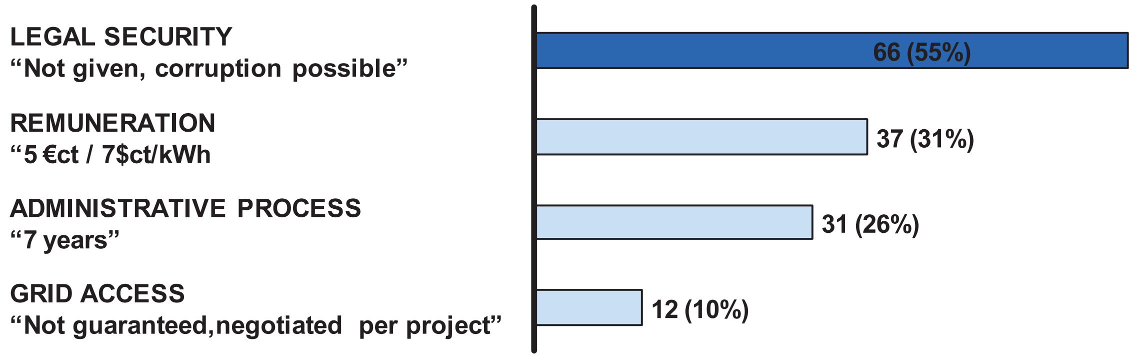


Figure 4.4: Number of respondents that regard given attribute levels as “unacceptable” for project development

Figure 4.5 shows how often certain attribute levels have been included in the winning scenario of the choice task section. The most frequent attribute level is “1 year” administrative process duration (55%), followed by “Guaranteed, priority dispatch” grid regulations (48%) and the most favorable levels for “Legal security” and “Remuneration” (47% and 45%, respectively). For all attributes, the preferences consistently decline from the most favorable to the least favorable level. The frequency of the attribute levels of “Financing support” and “Cash grants” cannot be analyzed because their appearance frequency was influenced by the included prohibitions.

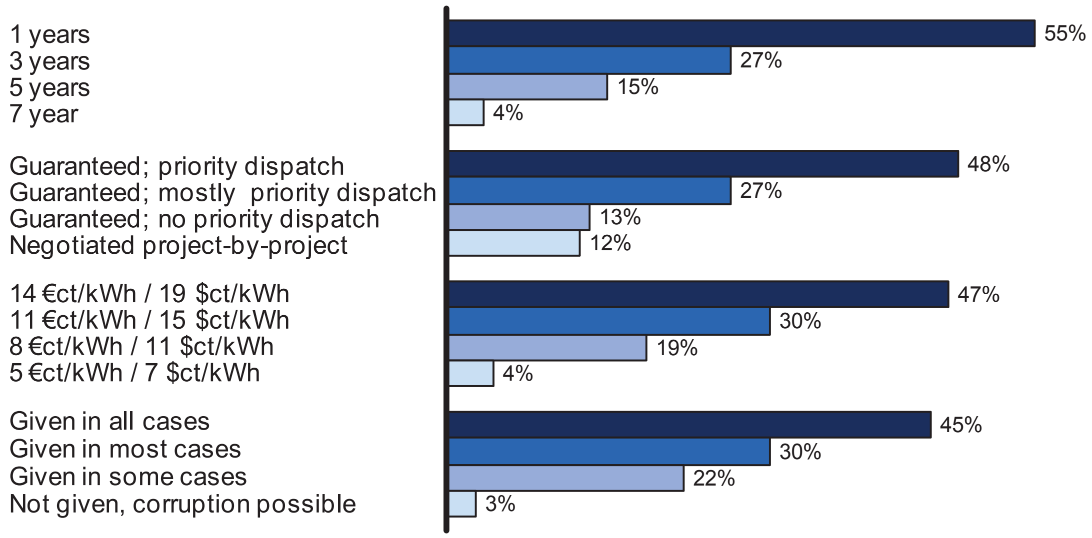


Figure 4.5: Share of attribute level appearance in winning scenarios

It is noteworthy that the two most preferred attribute levels in the winning scenarios ("1 year" and "Guaranteed; priority dispatch") are not from the attributes with the highest importance scores ("Legal security" and "Remuneration"). While the importance scores discussed above indicate the attributes for which developers show the largest preference differences between the worst and best levels, the winning scenario analysis provides insights into which aspects are most important to developers when they are looking for the ideal set of policy conditions in an investment environment. The results thus underline the high importance of short administrative processes during the development phase and grid access regulations that strictly favor renewable energy.

4.4.3 Part-worth Utility Estimation

Table 4.6 shows the average zero-centered diff part-worth utilities and standard deviations for all attributes levels.

Table 4.6: Part-worth utilities (zero-centered diffs) and standard deviations for all attributes and levels

Attribute	Attribute Levels	Average Part-worth Utility	Standard Deviation
Administrative process duration	7 year	-59.2	33.8
	5 years	-8.1	14.3
	3 years	28.1	16.7
	1 years	39.1	27.7
Legal security	Not given; corruption possible	-110.7	56.4
	Given in some cases	15.6	18.3
	Given in most cases	39.0	22.1
	Given in all cases	56.1	31.5
Grid access	Negotiated project-by-project	-27.5	23.3
	No priority dispatch	-7.0	16.9
	Mostly priority dispatch	14.8	12.4
	Priority dispatch	19.8	19.2
Total remuneration	5 €ct/kWh/ 7 $ct/kWh	-93.4	42.7
	8 €ct/kWh/ 11 $ct/kWh	-8.0	19.2
	11 €ct/kWh/ 15 $ct/kWh	34.1	21.6
	14 €ct/kWh/ 19 $/kWh	67.3	33.2
Credit financing	No support	-15.0	18.7
	Gov. guaranteed soft loans 0.5% below market rate	4.2	14.1
	Gov. guaranteed soft loans 1% below market rate	2.9	12.6
	Gov. guaranteed soft loans 1.5% below market rate	7.9	14.4
Investment cash grants	0%	-31.9	23.3
	10%	-7.1	11.6
	20%	12.3	17.4
	30%	26.7	16.6

Due to the considerations mentioned in section 4.2.4, we compared the utility differences between the different levels of each attribute (cf. Figure 4.6). In general, the amelioration of the worst situation delivered the highest utility gain. This is especially true for improving “Legal security” from “Not given; corruption possible” to “Given in some cases” (+126 utility points) and “Remuneration” level from “5 €ct/kWh/ 7$ct/kWh” to “8 €ct/kWh/ 11 $ct/kWh” (+85 utility points). This finding corresponds well with the “unacceptables” identified above and explains the high importance scores of “Legal security” and “Remuneration.” The low utility of the worst levels of these attributes (from people marking it as unacceptable) gives the importance scores a boost.

Any further improvement to the second and third best level of each attribute yields diminishing utility increases. There are only two notable exceptions: first, in the case of the attribute “Remuneration”, respondents value the two subsequent increases of 3€ct/kWh/ 4 $ct/kWh revenue with similar utility gains. This makes sense as the impact on project profitability is equal. Second, in the case of “Grid access”, the improvement from level 2 (“No priority dispatch”) to level 3 (“Mostly priority dispatch”) yields the highest utility gain within this attribute indicating the importance of priority dispatch for project developers.

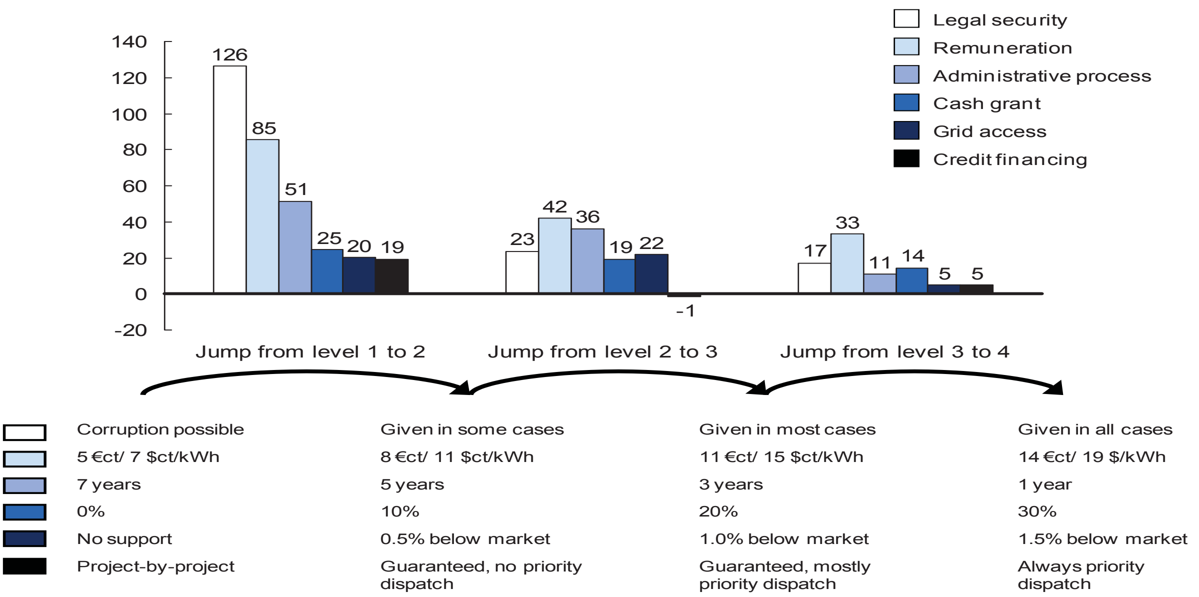


Figure 4.6: Part-worth utility gains (zero-centered diffs) for improvement to the next higher level within a specific attribute

4.4.4 Differences in preference data

To test for preference differences with respect to geographic focus of development activities, we clustered the respondents into three regional groups (U.S., NW- and SE-Europe). Table 4.7 presents an indicative assessment of the relevant criteria based on the expert interviews. While the conditions for wind energy projects are mainly specific to national policy regimes in Europe and state policy regimes in the U.S., the defined regions share some characteristics.

Table 4.7: Characteristics of wind markets in different regions (two moons indicate variations within the region)

○ = very low
● = very high

Criteria \ Countries	US	Northwest Europe	Southeast Europe
	US	Germany, Netherlands, Belgium, UK, Ireland, Sweden, Denmark, Austria, France, Norway, Finland	Bulgaria, Croatia, Greece, Italy, Poland, Romania, Slowenia, Spain, Turkey, Bulgaria, Portugal, Czeck Republic, Slowakia, Serbia
Maturity of wind market	◑	◑ / ◕	◔ / ◑
Legal security	◕	◕	◑ / ◕
Grid capacity for wind power	◔ / ◑	◑	○ / ◑
Administrative effectiveness	◕ / ●	◕	◑
Share of debt financing for wind energy projects	◔ / ◑	◕	◕

We found the wind energy development market to be quite international; German and Danish development companies have expanded their business into other European countries, many with a focus on Eastern and Southeastern Europe. A precise one to one allocation of respondents to regional groups is difficult as the majority of developers are active in two or three regions (only 45 out of the 108 respondents who indicated their activity countries confine their development activities to only one of the specified regions). As an approximation, we based regional clustering of respondents on where the majority of their development activities take place (number of mentioned countries). This led to some overlap of preferences and diffused regional discrepancies to some extent. ANOVA was conducted to assess significant differences between groups. If the variable F from the ANOVA was significant, a Gabriel *post hoc* test was conducted to see which specific groups showed significant differences (Field, 2009). The p-values reported below are those derived through the Gabriel *post hoc* procedure. Differences that were not statistically significant are discussed as indicative trends.

Figure 4.7 (left) displays the regional differences of the importance scores. In general, the preference differences between the regional clusters were small. This makes sense, as, in theory, the impact of cash flows and risks resulting from the different attribute levels on project profitability and project quality should be in the same order of magnitude in different regions. However, the similarity was also due to the non-bijective regional allocation of respondents. Using only the 45 respondents ("pure groups") with activities in a single region, most discrepancies were more pronounced (cf. Figure 4.7 (right)). The "pure groups" results were indicative only, given the rather small sample sizes for such groups in each region (SE: n=13 / NW: n=13 / U.S.: n=19).

We found three main differences in the preference structure of wind energy project developers from the three different regions.

The U.S. developers seem to have a higher preference for short-term support ("Cash grant") and place less value on "Remuneration" during the operational phase of the wind project compared to the European developers. This could imply an implicit higher discount rate when evaluating development options. The analysis of the underlying part-worth utilities (cf. Annex) indicates that the U.S. developers derive significant higher utility from cash grants above 20% and see the absence of a cash grant support as much worse than the NW-European developers. On the other hand, the U.S. developers have lower importance scores for "Remuneration", mainly driven by the fact that they are more willing to accept the lowest remuneration level of 7$ct/kWh. The analysis of the "pure groups" indicates that this difference in preference is most pronounced between the U.S. and SE-European developers. The latter place higher value on remuneration to compensate for comparatively higher development risks (especially the possibility of corruption).

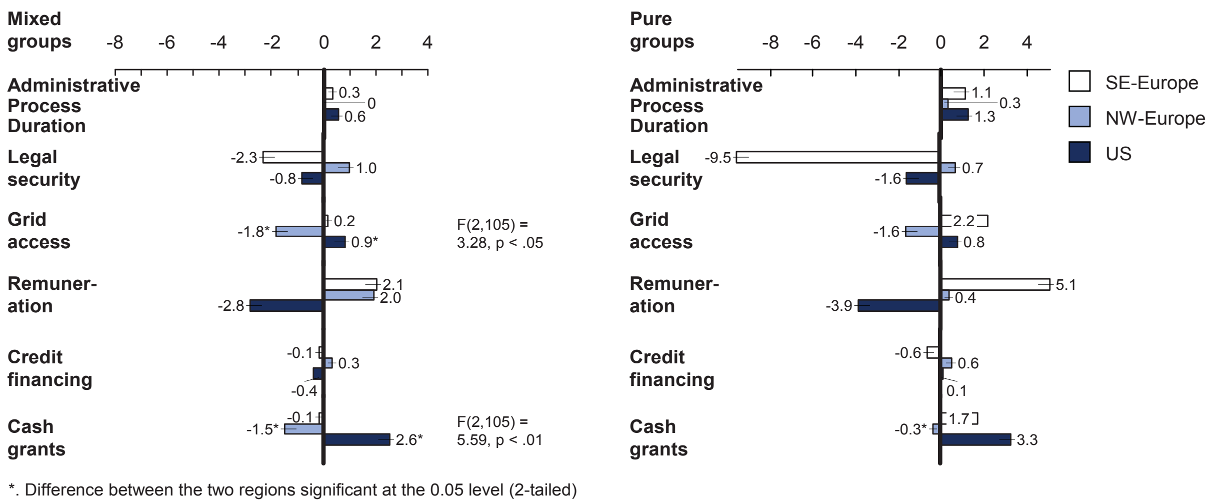


Figure 4.7 : Regional differences in importance scores – left: mixed groups, right: pure groups

The SE-European developers have a lower importance score for "Legal security" than both the NW-European and the U.S. developers. The part-worth utility comparison shows that this is mainly because the SE-European developers tend not to see corruption as a knock-out criterion, contrary to the other two developer groups (cf.

Annex). This difference is even more pronounced in the “pure groups”; with a large difference between the SE- and NW-European developers.

“Grid access” seems to be a less severe bottleneck for the NW-European developers than for the U.S. and SE-European wind energy developers. Their importance score is significantly lower because, on the one hand, they have less negative part-worth utilities for project-by-project negotiations and grid regulations without priority dispatch for wind, and on the other hand, value priority dispatch significantly less than other developers (cf. Annex). The developers from the U.S., for instance, show a much higher preference (+15 utility points) for a priority dispatch provision. The explanation for these differences could be that, in the U.S., most jurisdictions do not provide for guaranteed priority dispatch of wind energy. This poses a significant risk to wind energy plant owners as frequency of wind power curtailments increases (e.g., in Texas in 2009, 17% of all potential wind energy generation was curtailed because of transmission inadequacy (Wiser and Bolinger, 2010)).

The observed differences in preference structures may 1) result from familiarity of the respondents with specific policy instruments, as in the case of higher preference for cash grants of the U.S. developers; 2) reflect region-specific barriers to wind energy project development, as in the case of the preference regarding grid access; or 3) reflect cultural factors, such as the prevalence of corruption which leads SE-European developers to accept lower legal security or the preference of U.S. developers for a higher discount rate which is shown by their higher preference for upfront cash grants and lower preference for remuneration. The importance scores for “Administrative process duration” are quite similar for developers from all three regions, in both mixed and pure groups.

Various other cluster analyses were conducted with respect to type, size and value chain focus of the developer companies, share of debt financing, and the respondents’ level of experience with wind energy development. However, many cluster analyses cannot be reasonably interpreted because of either insufficient sample sizes of the clustered subgroups[17] or insignificant differences between them[18]. The fact that there are surprisingly little discrepancies in policy preferences between different groups of developers may be a finding in itself.

[17] Company type: Utilities (<10) vs. IPPs (<10)/ Development phase: pure late stage (financing or construction) (<10)

[18] No significant differences with respect to low and high “Share of debt financing”, and small and big “Size of company”

4.4.5 Region Specific Policy Analysis

Preference simulations based on the conjoint analysis experiment data allow the gauging of the investment intent of wind energy project developers under specific policy conditions. Using formula [5], they provide a means of simulating the preference for a given policy environment as if in a stand-alone context, without having to contrast it to a set of alternatives. $p = \frac{e^u}{1+e^u}$The simulations allow testing the extent to which the relative preferences *p* change when the levels of an attribute change, while keeping all other attribute levels constant. For each policy environment, changes in policy measures will have a different impact on the country's attractiveness for project developers. The preference simulations are not to be interpreted literally but are meant to serve as a gauge or "barometer" for investment intent. We have constructed three illustrative scenarios of attribute level settings that roughly reflect Northwest- (NW-) Europe (scenario 1), Southeast- (SE-) Europe (scenario 2)[19] and the U.S. (scenario 3) (cf. Table 4.8). Note that the scenario simulations shown here are based on the preference data of the entire sample to make them more robust and allow for a variety of scenarios.

Table 4.8: Illustrative policy scenarios representative of the regions NW-Europe, SE-Europe and U.S

Attributes	NW-Europe	SE-Europe	U.S.
Administrative process duration	3 years	7 years	2 years
Legal security	Given in all cases	Given in some cases	Given in all cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Negotiated on project-by-project basis
Total remuneration	8 €ct/kWh	11 €ct/kWh	5 €ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	No support	No support
Investment cash grants	0%	10%	30%
Relative preference	83.33	31.02	38.36

Scenario NW-Europe

The hypothetical NW-Europe scenario (Figure 4.8) has a high relative preference of 83%, mainly due to low policy risks (highest levels of "Legal security" and "Grid access"). Significant increase in perceived market attractiveness can only be reached by additional financial support. A "Remuneration" increase of 3€ct/kWh to 11€ct/kWh

[19] As corruption is possible in many SE-European countries, we decided not to include this level in our simulation, as it has been shown (section 4.2) that corruption is a knock-out criterion for many developers and should thus be addressed first.

or the introduction of a 10% “Cash grant” would yield the highest gain for developers (+11% and +9%, respectively). As the current market attractiveness is quite high, further policy changes need to be evaluated carefully to avoid over-subsidization. On the flip side, a reduction of the “Remuneration” would be very detrimental to the relative preference (-48%) and have serious implications for wind energy development activities in this market.

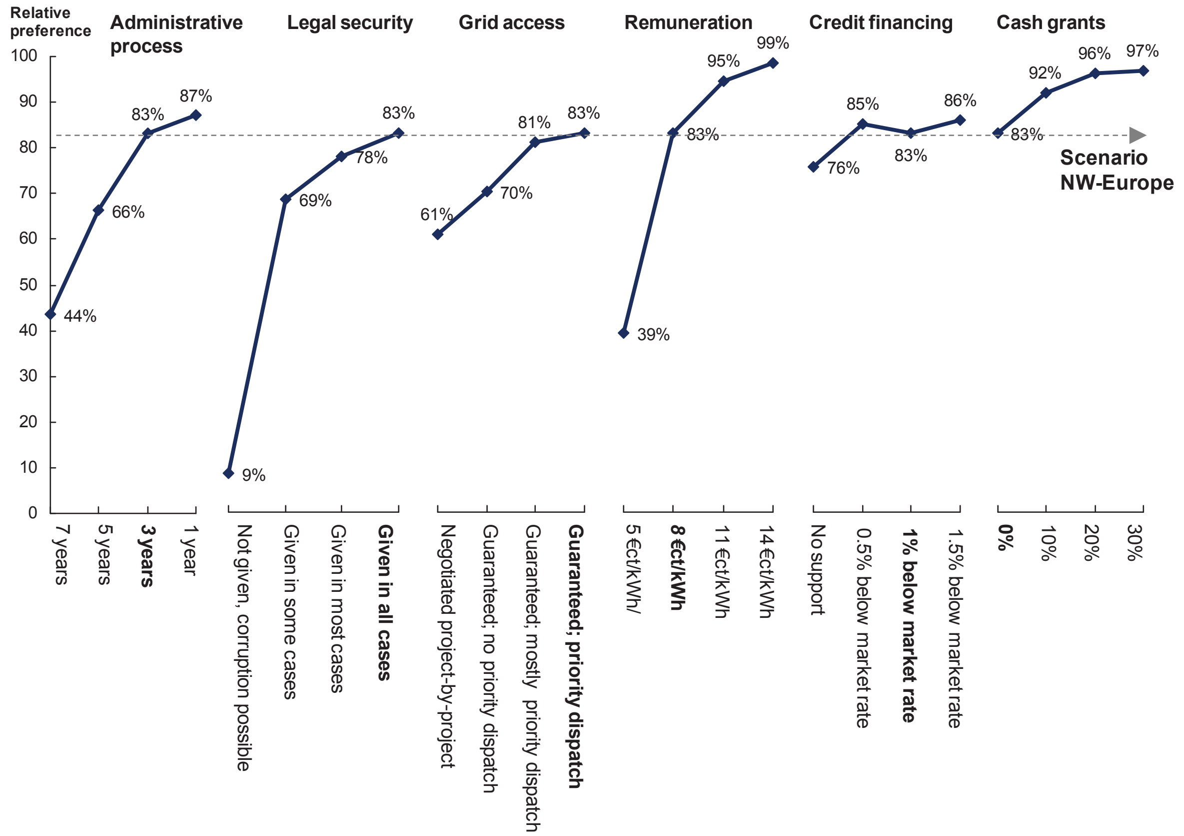


Figure 4.8: Relative preference simulations for the NW-Europe scenario

Scenario SE-Europe

The hypothetical scenario for SE-Europe (Figure 4.9) has a relative preference of 31%. The attractiveness of this policy framework can be strongly increased by shortening the “Administrative process duration”. A shorter process would increase the preference share to 62% (5 years) or to 82% (3 years). Substantial improvements could also be achieved by improving “Legal security”, “Remuneration” or “Grid access”.

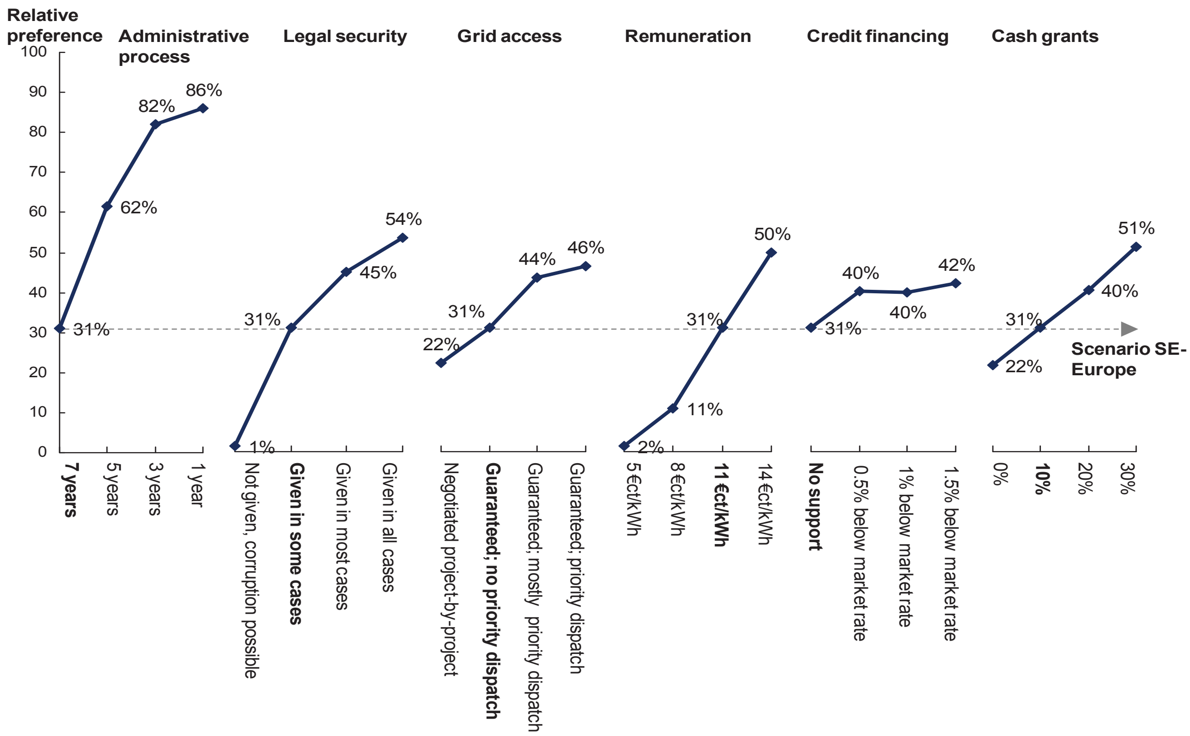


Figure 4.9: Relative preference simulations for the SE-European scenario

Scenario U.S.

The hypothetical U.S. scenario (Figure 4.10) has a relative preference of 38%. Its attractiveness would benefit most from increasing the "Remuneration" (+46% for an increase from 5 to 8 €ct/kWh). The reason is that the four levels within this attribute (5/ 8/ 11/ 14 €ct) have unevenly distributed part-worth utility values – the jump from 5€ct to 8 €ct delivers by far the highest gain (see Figure 4.6). This is the case in any scenario with a low remuneration level. While this effect dominates, it does not contradict the finding from the importance score analysis above which showed that U.S. developers do not value the attribute "remuneration" in comparison to other attributes quite as much as developers from other regions. If we take into account only preference data of SE-European developers, the effect would be more pronounced than in the case of U.S. developers data.

Improving "Grid access" so that priority dispatch is mostly given yields an increase of +24% in the relative preference. An increase in the relative preference of the scenario could also be reached by "Credit financing" opportunities. The introduction of government guaranteed soft loans 1% below market rate would increase the attractiveness of the base case scenario by 10%.

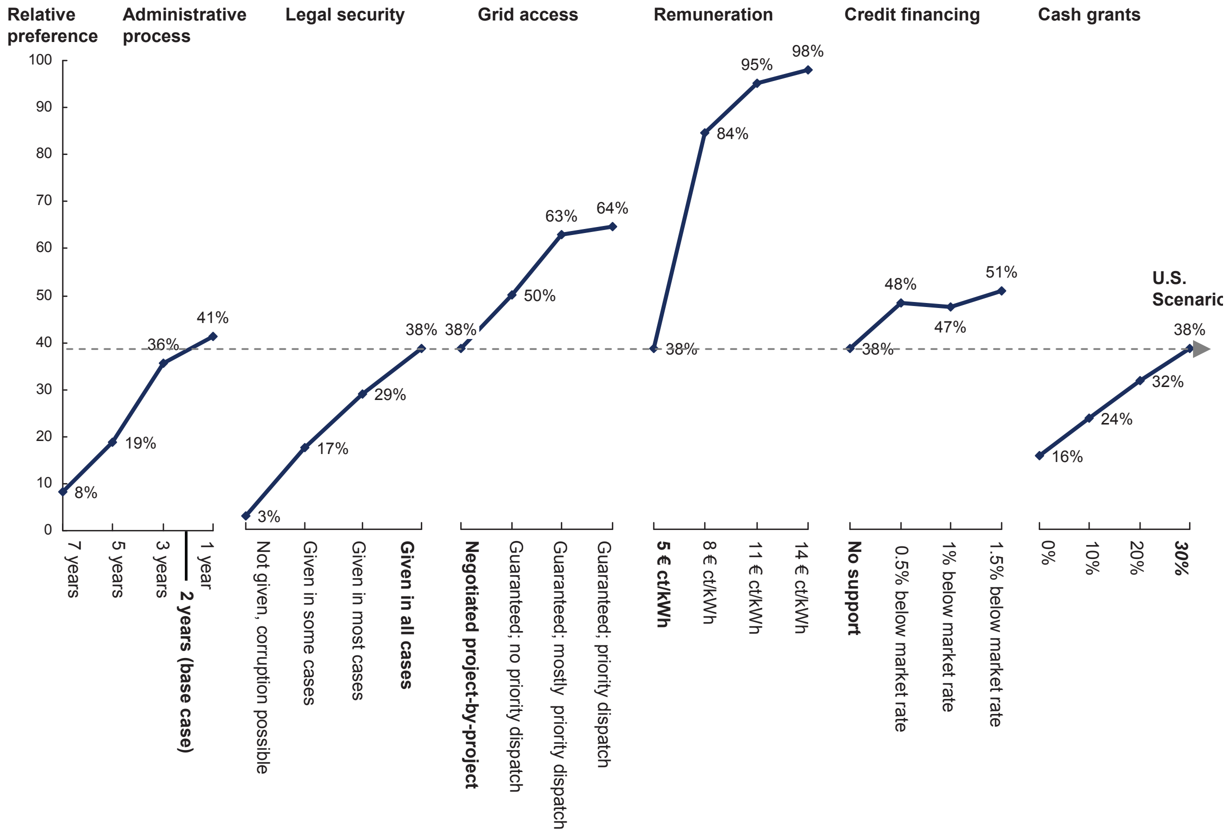


Figure 4.10: Relative of preference simulations for the U.S. scenario

The importance score analysis in section 4.4.4 showed for which aspects and by how much the preferences of developers from different regions differ. This can be important for policy makers, for example, when adopting best practice policies from other regions. While the described regions share some common characteristics, policy makers usually act on a national level. The results from the scenario analysis in section 4.4.5 give guidance on which policy improvements could provide the highest utility gains for developers given a specific (national) context[20]. This section showed that the respective starting point is crucial to understand in which areas policy improvements have the biggest impact on developers' utility.

4.5 Conclusion

4.5.1 Summary and implications for policy-makers and project developers

The objective of this paper was to examine project developers' policy preferences to enhance the deployment of wind energy. This study builds on the findings of existing

[20] While the presented scenarios are illustrative for regions, the data could be used to conduct similar analyses on a national level.

literature and substantiates them by employing a novel research methodology, providing an empirical dataset of wind developers' preferences and making the impact of various policy factors on developers' utility measureable. It also suggests that conjoint analysis could be a helpful tool for the estimation of potential effects of specific policy measures.

Key findings can be summarized as follows:

First, wind energy project developers value risk mitigation highly. Legal security, short administrative process duration and favorable grid access regulations are very important to developers. These findings are in line with the conclusions of previous studies (Langniss, 1996; Wiser and Pickle, 1998; Dinica, 2003; Del Río and Gual, 2007 among others) and confirm their results with empirical preference data. "Legal security" and "Remuneration" have the highest importance scores, whereas, when selecting the most preferred policy scenario, developers indicated the highest preference for very short "Administrative process duration" and "Grid access" regulation that guarantees priority dispatch.

Second, developers have critical minimum requirements for development and as a result they use non-compensatory decision-making in the case of very unfavorable attributes. More than 50% of the wind energy developers see the possibility of corruption, and about 30% see the lowest remuneration level included in the study (5€ct/kWh respective 7$ct/kWh) and an administrative process duration of 7 years, as knock-out criteria. The study also shows that in most cases, the amelioration of the worst situation brings the highest utility gain.

Third, the preferences of the surveyed developers from the three different regions are generally quite similar, but show some differences resulting from different regional wind energy barriers, familiarity with different policy instruments, and cultural factors. First, the U.S. developers show a higher preference for upfront investment cash grants and a lower preference for production-based remuneration than the European developers. This difference could be caused by an implicitly higher discount rate of the U.S. developers or policy schemes familiarity (i.e., U.S. developers are more familiar with cash grants, while European developers are more familiar with a feed-in tariff support scheme). Second, in SE-Europe where corruption is comparatively more common, this issue tends to be seen as less problematic. In return, the remuneration expectations are higher. Third, the U.S. and SE-European developers state a higher preference for grid access regulations that secure priority dispatch for wind energy than NW-European developers. The latter usually have the benefit of such provisions and the former experience the lack thereof and thus have higher awareness for the need.

Fourth, the most valuable policy measures for developers differ depending on the specific policy framework in place. The preference simulations indicate that in a scenario emulating SE-Europe, streamlining of the administrative processes and increasing legal security are of the highest value to increase market attractiveness. In the U.S. scenario, improvements in grid access regulation and higher remuneration would render the development of wind power plants more attractive. In the NW-Europe scenario, market attractiveness is already very high and could only be significantly enhanced further by higher financial support.

These results have important implications for policy design:

- When designing support policies for wind energy promotion, policy-makers should focus on risk minimization measures, especially regarding legal security, administrative process duration and grid access issues (compare Bürer and Wüstenhagen, 2009; Lüthi, 2010).
- Policy-makers should first address knock-out criteria such as corruption and very low remuneration to avoid obstacles to the deployment of wind energy.
- When designing support policies, policy-makers should take into account that the most effective support measures are strongly dependent on the current policy environment. The illustrative regional analyses can help policy-makers to identify the policy measures that result in the biggest utility impact in the developer community and to gauge the relative importance of these changes in terms of preference increase for project developers.
- Finally, the result that the preferences of the surveyed developers from the three different regions are generally quite similar indicates that the results of this study are transferable to individual countries or other regions with comparable investment environments. However, when designing or changing wind energy policies, policy-makers should take into account support policy familiarity of the project developers active in their region, cultural factors like investment discount rate and, as mentioned above, especially address problems that are of primary concern for the development of wind energy projects in their region.

The results of this study are also relevant to wind energy project developers and allow them to learn more about their own decision-making and gain insights that help them benchmark their decision-making process with industry peers.

4.5.2 Limitations and Further Research

This study suggests that conjoint analysis can serve as a useful scenario tool for assessing the effect of policy measures on developer utility, but there are several limitations regarding its use which should be taken into account in further studies. First, the insights are based on stated preferences and not on revealed actual behavior. What developers say about their decision-making process might be different from how they decide in reality. Real life complexity cannot be mirrored 100% with a limited number of attributes. This tends to lead to overestimation of the studied aspects. Second, preference simulations based on conjoint analysis data do not provide the functionality of a market model. Aspects such as competition, demand, capital availability or alternative investment options in other forms of energy generation are not considered. Hence, our results inform about preference of developers for policy measures, but they cannot predict market reactions. Third, the study does not specifically recognize national business cultures. Dinica showed, for example, that the risk aversion of Spanish wind power investors could initially only be overcome with government participation via public-private partnerships and even now the business culture is still dominated by partnership investments (Dinica, 2008).

Our findings could be extended by further research in other regions, such as developing countries. Such a study would need to consider including other region specific attributes such as overall political stability, investment costs and currency risk. Similarly, a study focusing on other renewable energy technologies would yield interesting results for comparison, but is likely to require other attributes to accommodate different economics and diffusion barriers. Further research could explore possibilities of linking stated preference data with actual revealed data such as wind capacity installations. This would allow the calibration of choice data with market data. These techniques have mainly been used in the study of travel choices (Hensher, Louviere et al., 2001). Another extension could be to include additional factors that potentially influence the project developers' choices such as competition levels, the influence of industry networks and the level of social acceptance of wind energy. Investigating preferences and motivations of other investor groups such as final asset owners can also add valuable insights.

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4.7 Annex

Table 4.9: Zero-centered diffs part-worth utilities and standard deviations (SD) for all attributes and levels for the total regional three regional groups (SE-Europe, NW-Europe and U.S.)

Attribute	Attribute Levels	Total Utility (SD)	SE-Europe Utility (SD)	NE-Europe Utility (SD)	U.S. Utility (SD)
Administrative process duration	7 year	-60.4 (33.3)	-60.8 (32.5)	-59.9 (32.5)	-60.5 (35.7)
	5 years	-8.3 (14.7)	-6.9 (15.2)	-8.1 (13.9)	-10.2(15.2)
	3 years	28.8 (16.6)	27.9 (17.7)	28.2 (15.2)	30.4 (17.3)
	1 years	39.9 (27.8)	39.7 (23.9)	39.8 (27.4)	40.3 (32.6)
Legal security	Not given; corruption possible	-107.4 (54.3)	-98.8 (59.0)	-113.2 (48.8)	-110.3 (55.1)
	Given in some cases	15.3 (18.0)	10.8 (15.6)	14.3 (17.1)	21.4 (20.1)
	Given in most cases	37.8 (21.2)	34.7 (24.0)	38.9 (19.4)	40.1 (19.9)
	Given in all cases	54.2 (29.2)	53.3 (34.6)	59.9 (26.6)	48.8 (24.9)
Grid access	Negotiated project-by-project	-25.5 (22.5)	-29.9 (19.4)	-19.4 (22.1)	-27.5 (25.1)
	No priority dispatch	-7.5 (17.2)	-6.4 (16.7)	-2.6 (15.1)	-13.9 (18.4)
	Mostly priority dispatch	14.3 (12.2)	14.5 (14.2)	12.7 (11.2)	15.7 (11.1)
	Priority dispatch	18.7 (18.9)	21.8 (17.8)	9.4 (18.2)	25.6 (17.3)
Total remuneration	5 €ct/kWh/ 7 $ct/kWh	-95.9 (42.0)	-100.8 (48.2)	-104.6 (32.1)	-81.0 (41.5)
	8 €ct/kWh/ 11 $ct/kWh	-7.5 (19.4)	-5.3 (18.3)	-5.4 (22.7)	-12.3 (16.2)
	11 €ct/kWh/ 15 $ct/kWh	34.6 (22.0)	34.9 (22.4)	39.2 (20.8)	29.3 (22.3)
	14 €ct/kWh/ 19 $/kWh	68.8 (33.0)	71.2 (38.5)	70.8 (28.8)	64.0 (31.0)
Credit financing	No support	-14.1 (18.9)	-15.7 (17.6)	-13.7 (23.4)	-12.8 (14.9)
	Gov. loans 0.5% below market rate	4.4 (14.4)	6.4 (12.5)	6.5 (16.0)	-.1 (13.8)
	Gov. loans 1% below market rate	2.1 (12.4)	.7 (11.4)	.6 (13.7)	5.3 (11.6)
	Gov. loans 1.5% below market rate	7.6 (14.8)	8.6 (14.5)	6.6 (16.8)	7.6 (13.0)
Investment cash grants	0%	-32.8 (24.0)	-32.0 (20.2)	-24.1 (22.9)	-43.2 (25.7)
	10%	-7.0 (11.6)	-6.4 (13.6)	-6.3 (10.1)	-8.4 (10.9)
	20%	12.8 (17.8)	10.6 (15.1)	7.6 (17.4)	20.9 (18.6)
	30%	27.0 (17.1)	27.7 (18.3)	22.9 (16.6)	30.6 (15.8)

4.8 Supporting Material

4.8.1 Affiliation and Experience of Interviewed Experts

#	Company	Home Country	Years of Experience in Wind Project Development	Number of Countries in Which Active
1	EuropeanEnergy	Denmark	3	6
2	EuropeanEnergy	Italy	3	4
3	BMU	Germany	-	1
4	EuropeanEnergy	Denmark	3	6
5	KFW Bank	Germany	10	1
6	UC Berkeley	USA	(research)	N/A
7	KFW Bank	Germany	-	0
8	McK	Italy	2	2
9	Repower	USA	3	2
10	LBNL	USA	(research)	N/A
11	"D.I.E.- Erneuerbare Energien"	Germany	10	2
12	PNE Wind AG	Poland	3	2
13	BEC Energie	Germany	22	3
14	Energiewerkstatt	Austria	10	6
15	Windkraft Nord	Germany	9	3
16	Familienunternehmen	Bulgaria	3	5
17	RDS Energies	Germany	5	3
18	Familienunter-nehmen	Bulgaria	3	5
19	EDP	Spain	5	7
20	Prokon	Germany	12	3
21	Windkraft Nord	Germany	20	6
22	LBNL	USA	(research)	N/A
23	Frescon	Poland	3	1
24	EON Renewables	Germany	8	4
25	Vattenfall	Germany	5	2

4.8.2 Expert Interview Guidelines

A. Basics:

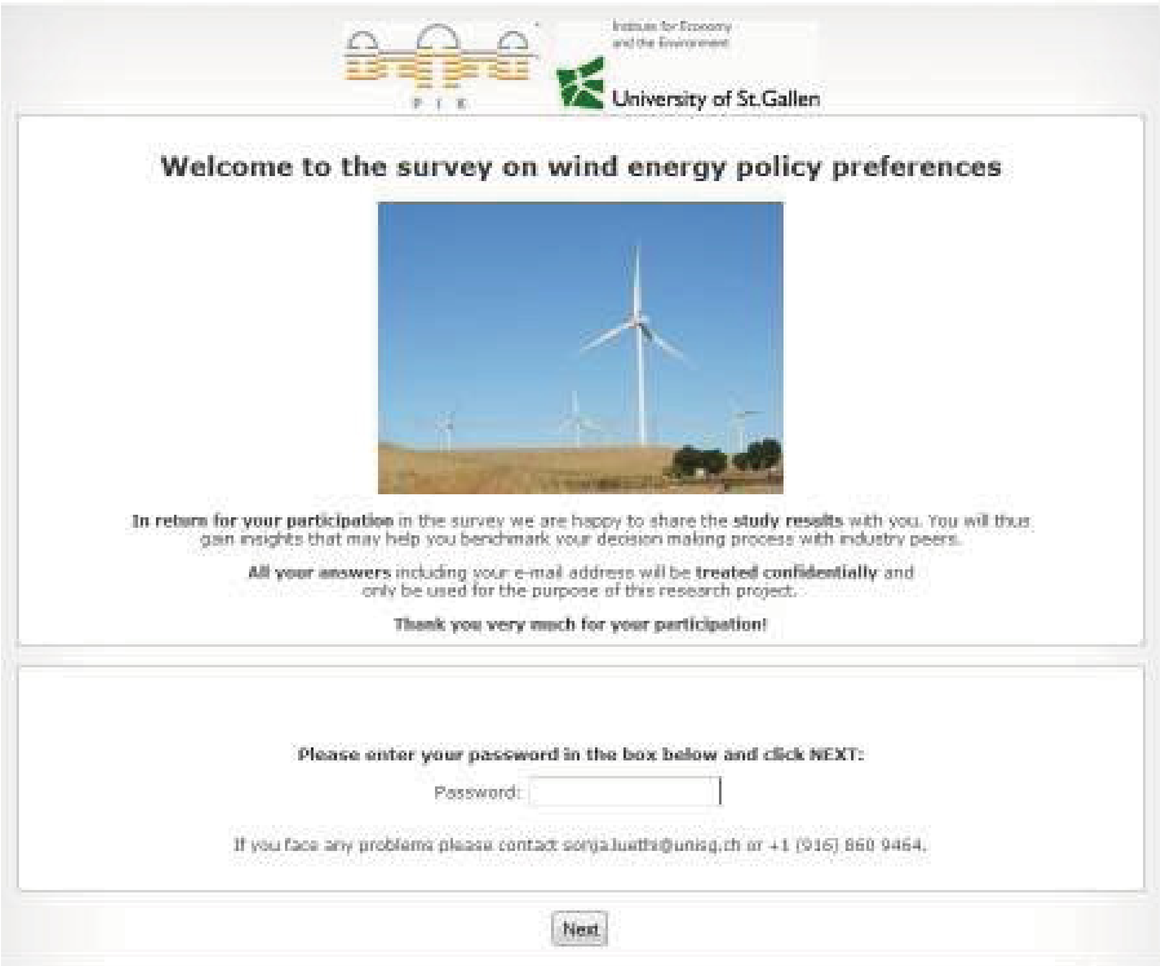
1. Interviewees
2. Type of company (Independent project developer, size)
3. Business model / playing field in value chain (e.g. Project development/Financial Engineering/Construction etc.) Self-operated plants vs. turn key sell off
4. What kind of projects are you developing
   - Size
   - Type (on-/offshore, green field projects, etc.)
   - Which countries?
   - Total experience in business (#installations / total MWs / years in business)

B. Role of policy & financing instruments for investment decision:

1. How are investment decisions planned?
2. What role does policy environment play for investment decision?
3. Which risk factors are most important for investment decision and how could they be included in the choice experiment?
4. Which are the most important support instruments for development decision?
5. How important are the following factors?
   - Numbers of applications, the number of involved authorities? How are delays costs and cash relevant?
6. What is the best way for us to get in contact details of developers for survey participation? Would you be willing to leverage your contacts?

4.8.3 Example of the adaptive choice based conjoint analysis (ACBC) online survey

The following print screens provide an exemplary survey.



Institute for Economy and the Environment

University of St.Gallen

Hi, my name is Kylie, and I will guide you through this survey.

Thank you for agreeing to take this survey! This interactive survey will take approximately 20 minutes to complete.

Imagine you were a wind energy project developer looking for a new project development opportunities and I was the colleague assisting you.

In the **first stage**, I will show you several possible policy conditions for **screening**. The objective is to identify the conditions that you'd be most likely to investigate further.

In the **second stage**, I will present to you the options that you have selected in the previous task and you will be asked to trade them off against each other until we **identify the option you like best** (like in a tournament).

Finally, I will ask some questions about you and your company.

For all of the following questions please assume you want to develop a generic onshore **wind power project of about 10 MW** at a high wind quality location that yields an **average capacity factor of ~25%** (~2200 full load hours). Please assume sufficient grid capacity is given.

But before we start this exercise, I'd like to know in which region you are currently primarly developing wind energy projects.

- Europe
- United States

Click the Next button below to continue...

Next

0% 100%

Institute for Economy and the Environment

University of St.Gallen

Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(1 of 7)

Administrative process duration	7 years	3 years	1 year	5 years
Legal security	Not given; corruption possible	Given in most cases	Given in some cases	Given in all cases
Grid access	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access not guaranteed, negotiated on project-by-project basis	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	11 US-ct/kWh	19 US-ct/kWh	7 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 0.5% below market rate	Gov. guaranteed soft loans 1.5% below market rate	No support	Gov. guaranteed soft loans 1% below market rate
Investment cash grants	0%	10%	30%	20%
	Would consider / Would not consider	Would consider / Would not consider	Would consider / Would not consider	Would consider / Would not consider

<< Next

0% 100%

Institute for Economy and the Environment
University of St.Gallen

Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(2 of 7)

Administrative process duration	3 years	1 year	7 years	5 years
Legal security	Given in all cases	Not given; corruption possible	Given in most cases	Given in some cases
Grid access	Access guaranteed; no priority dispatch (output curtailment is likely)	Access not guaranteed, negotiated on project-by-project basis	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	15 US-ct/kWh	19 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	No support	Gov. guaranteed soft loans 0.5% below market rate	Gov. guaranteed soft loans 1.5% below market rate
Investment cash grants	0%	10%	20%	30%
	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider

<< Next

0% 100%

Institute for Economy and the Environment
University of St.Gallen

Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

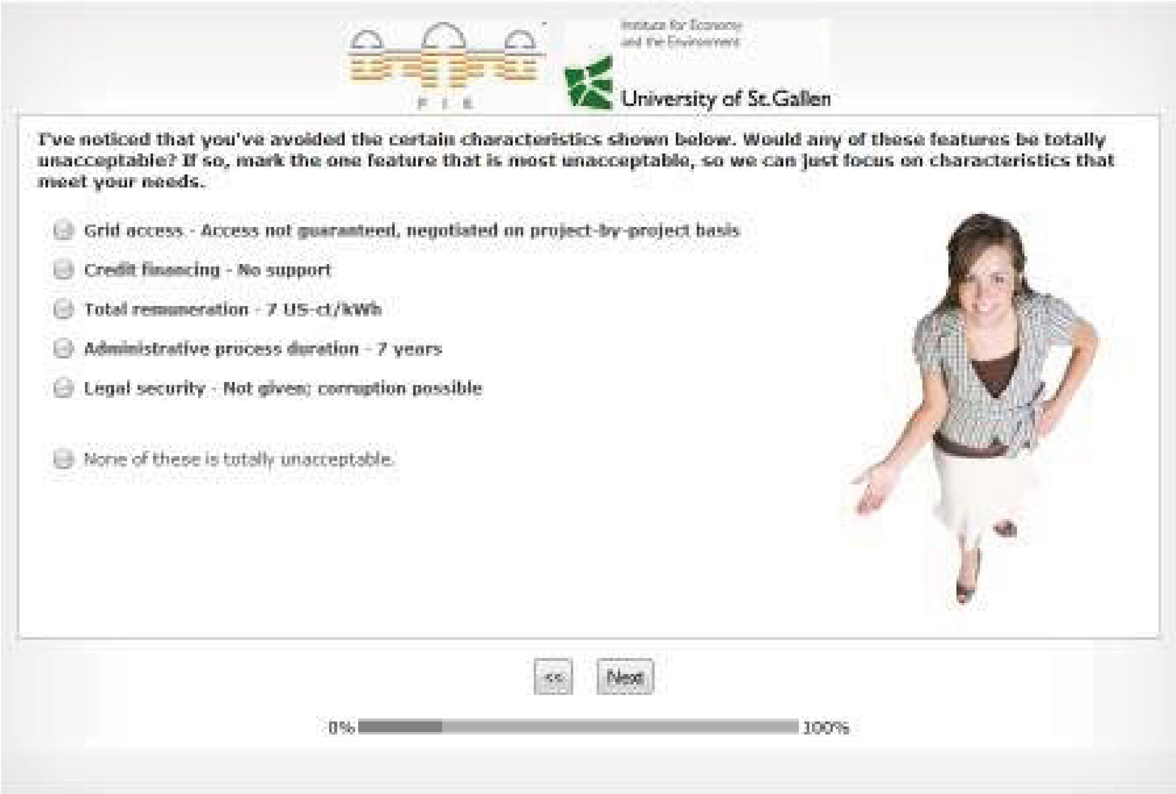
Some explanations are provided when you move your cursor over the respective words.

(3 of 7)

Administrative process duration	3 years	7 years	1 year	1 year
Legal security	Given in most cases	Given in some cases	Not given; corruption possible	Given in most cases
Grid access	Access not guaranteed, negotiated on project-by-project basis	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access not guaranteed, negotiated on project-by-project basis
Total remuneration	7 US-ct/kWh	15 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	No support	Gov. guaranteed soft loans 0.5% below market rate	No support
Investment cash grants	30%	10%	0%	10%
	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider

<< Next

0% 100%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I've noticed that you've avoided the certain characteristics shown below. Would any of these features be totally unacceptable? If so, mark the one feature that is most unacceptable, so we can just focus on characteristics that meet your needs.

- Grid access - Access not guaranteed, negotiated on project-by-project basis
- Credit financing - No support
- Total remuneration - 7 US-ct/kWh
- Administrative process duration - 7 years
- Legal security - Not given; corruption possible

- None of these is totally unacceptable.

<< Next

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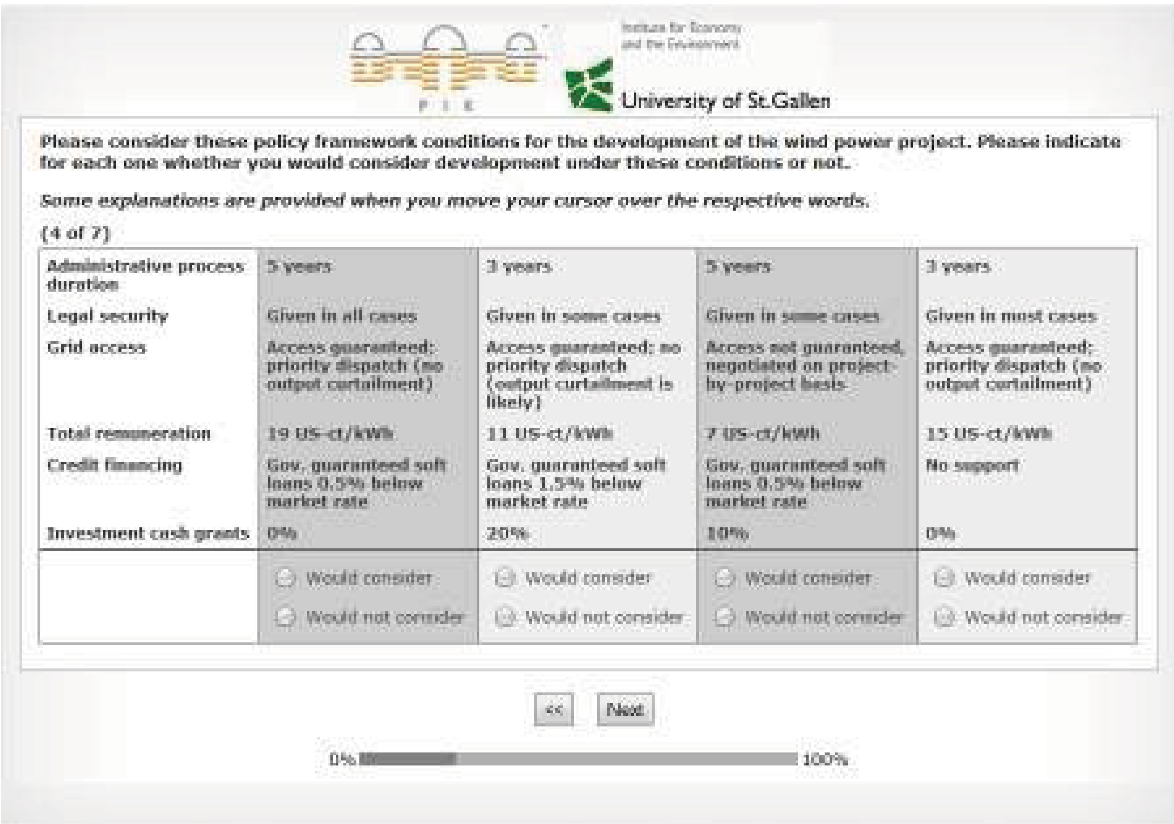
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Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(4 of 7)

Administrative process duration	5 years	3 years	5 years	3 years
Legal security	Given in all cases	Given in some cases	Given in some cases	Given in most cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access not guaranteed, negotiated on project-by-project basis	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	19 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 0.5% below market rate	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 0.5% below market rate	No support
Investment cash grants	0%	20%	10%	0%
	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider	Would consider Would not consider

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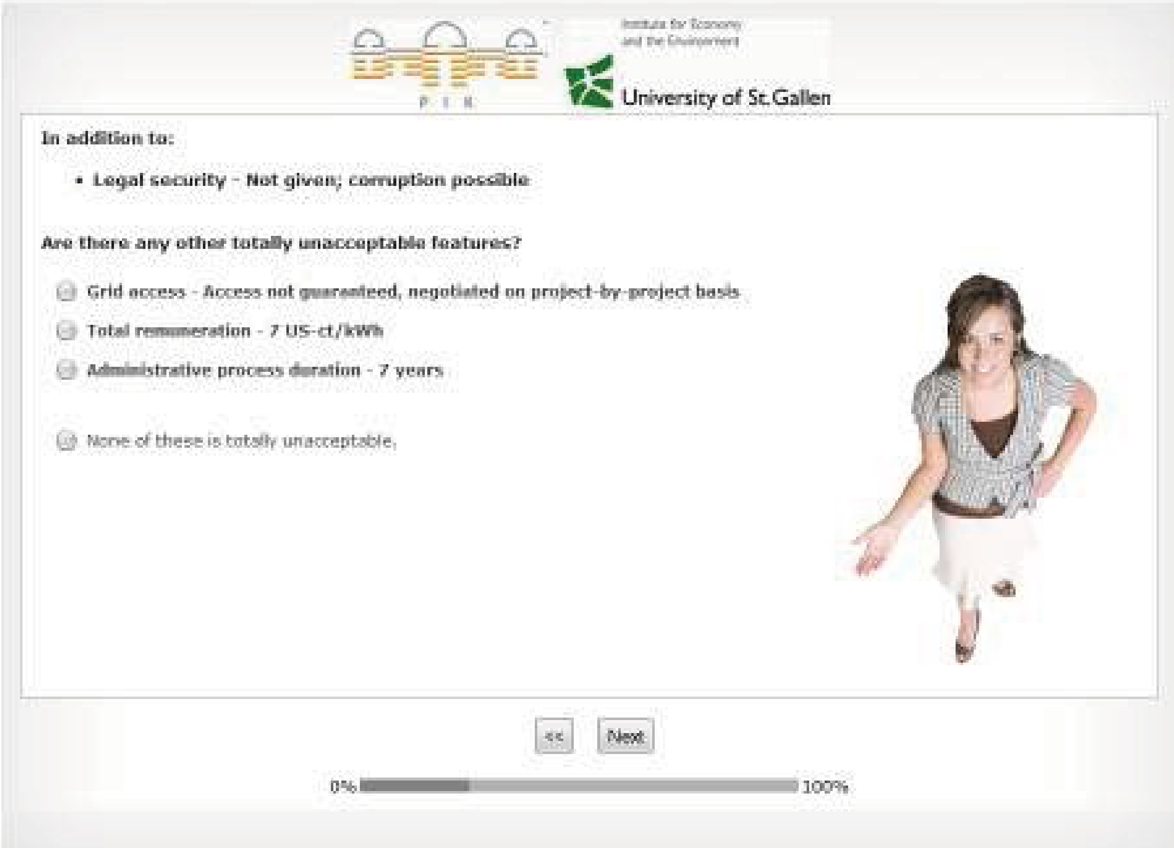
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In addition to:
• Legal security - Not given; corruption possible
Are there any other totally unacceptable features?
Grid access - Access not guaranteed, negotiated on project-by-project basis
Total remuneration - 7 US-ct/kWh
Administrative process duration - 7 years
None of these is totally unacceptable.
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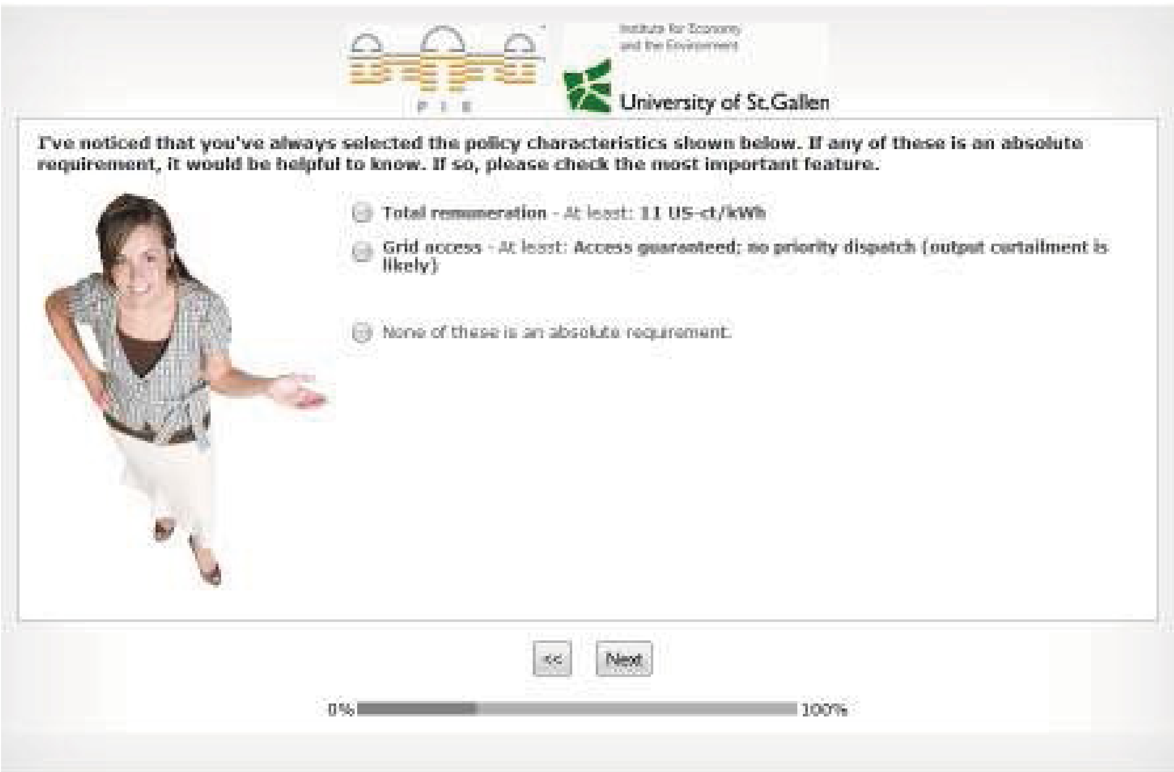
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and the Environment
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I've noticed that you've always selected the policy characteristics shown below. If any of these is an absolute requirement, it would be helpful to know. If so, please check the most important feature.
Total remuneration - At least: 11 US-ct/kWh
Grid access - At least: Access guaranteed; no priority dispatch (output curtailment is likely)
None of these is an absolute requirement.
<<
Next
0%
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Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(5 of 7)

Administrative process duration	1 year	5 years	3 years	1 year
Legal security	Given in some cases	Given in most cases	Given in all cases	Given in most cases
Grid access	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	11 US-ct/kWh	7 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 0.5% below market rate
Investment cash grants	0%	10%	0%	10%
	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider

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Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(6 of 7)

Administrative process duration	3 years	1 year	1 year	3 years
Legal security	Given in all cases	Given in most cases	Given in most cases	Given in some cases
Grid access	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	7 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh	11 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 0.5% below market rate
Investment cash grants	0%	10%	20%	10%
	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider

<< Next

0% 100%

Institute for Economy and the Environment

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Please consider these policy framework conditions for the development of the wind power project. Please indicate for each one whether you would consider development under these conditions or not.

Some explanations are provided when you move your cursor over the respective words.

(7 of 7)

Administrative process duration	3 years	5 years	5 years	1 year
Legal security	Given in most cases	Given in some cases	Given in some cases	Given in most cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	7 US-ct/kWh	15 US-ct/kWh	7 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1.5% below market rate	No support	Gov. guaranteed soft loans 1% below market rate	No support
Investment cash grants	30%	0%	20%	0%
	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider	○ Would consider ○ Would not consider

<< Next

0% 100%

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(1 of 7)

Administrative process duration	1 year	3 years	3 years
Legal security	Given in most cases	Given in most cases	Given in some cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	15 US-ct/kWh	7 US-ct/kWh	11 US-ct/kWh
Credit financing	No support	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 0.5% below market rate
Investment cash grants	0%	30%	10%
	○	○	○

<< Next

0% 100%

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(2 of 7)

Administrative process duration	3 years	1 year	3 years
Legal security	Given in all cases	Given in some cases	Given in most cases
Grid access	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	11 US-ct/kWh	11 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1% below market rate	No support
Investment cash grants	0%	0%	0%
	○	○	○

<< Next

0% 100%

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(3 of 7)

Administrative process duration	5 years	3 years	5 years
Legal security	Given in all cases	Given in all cases	Given in all cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	19 US-ct/kWh	15 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 0.5% below market rate	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1% below market rate
Investment cash grants	0%	0%	20%
	○	○	○

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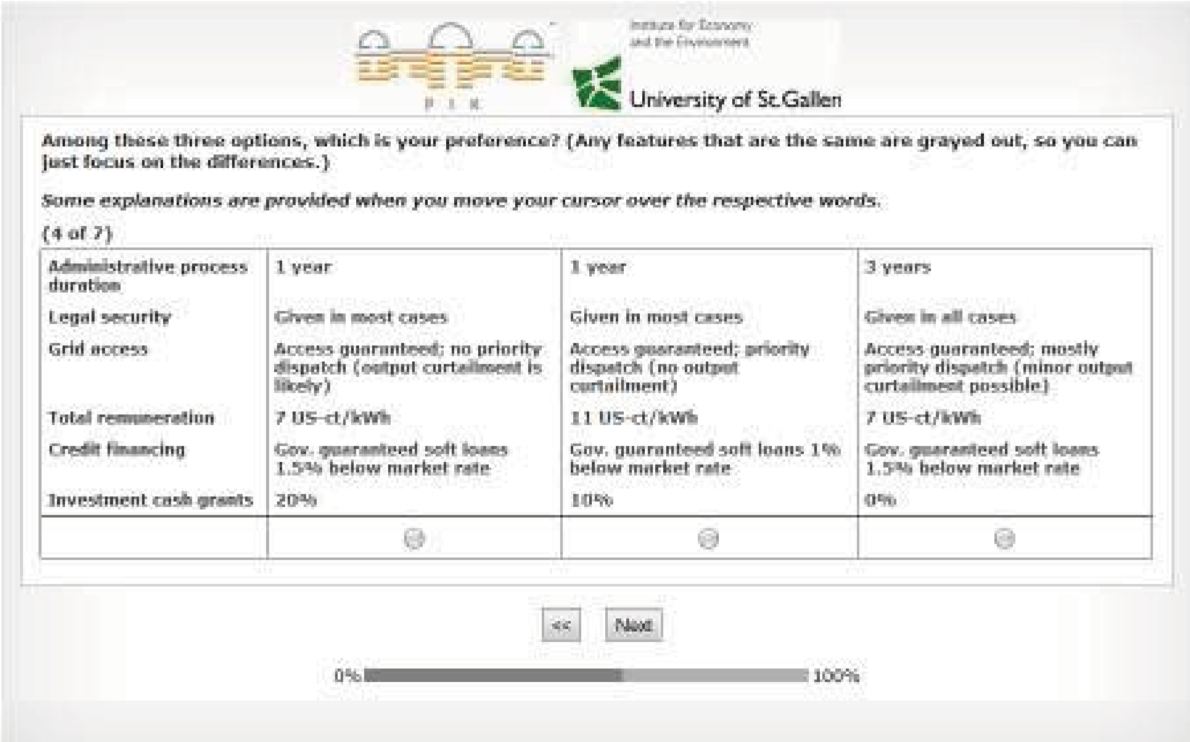

PIK

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(4 of 7)

Administrative process duration	1 year	1 year	3 years
Legal security	Given in most cases	Given in most cases	Given in all cases
Grid access	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)
Total remuneration	7 US-ct/kWh	11 US-ct/kWh	7 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 1% below market rate	Gov. guaranteed soft loans 1.5% below market rate
Investment cash grants	20%	10%	0%

<< Next

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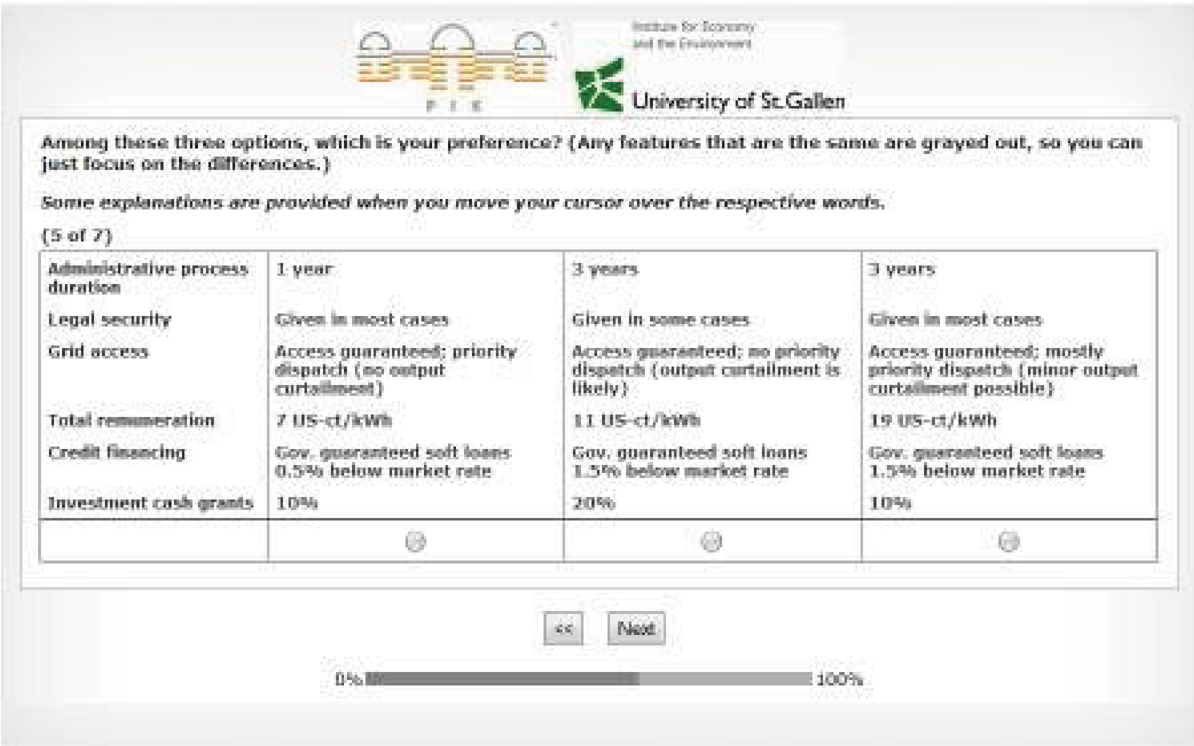

PIK

Institute for Economy and the Environment

University of St.Gallen

Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(5 of 7)

Administrative process duration	1 year	3 years	3 years
Legal security	Given in most cases	Given in some cases	Given in most cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; mostly priority dispatch (minor output curtailment possible)
Total remuneration	7 US-ct/kWh	11 US-ct/kWh	19 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 0.5% below market rate	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 1.5% below market rate
Investment cash grants	10%	20%	10%

<< Next

0% 100%

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(6 of 7)

Administrative process duration	1 year	3 years	3 years
Legal security	Given in most cases	Given in most cases	Given in all cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)
Total remuneration	15 US-ct/kWh	15 US-ct/kWh	15 US-ct/kWh
Credit financing	No support	No support	Gov. guaranteed soft loans 1% below market rate
Investment cash grants	0%	0%	0%

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Among these three options, which is your preference? (Any features that are the same are grayed out, so you can just focus on the differences.)

Some explanations are provided when you move your cursor over the respective words.

(7 of 7)

Administrative process duration	3 years	1 year	1 year
Legal security	Given in most cases	Given in most cases	Given in most cases
Grid access	Access guaranteed; mostly priority dispatch (minor output curtailment possible)	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	19 US-ct/kWh	11 US-ct/kWh	15 US-ct/kWh
Credit financing	Gov. guaranteed soft loans 1.5% below market rate	Gov. guaranteed soft loans 1% below market rate	No support
Investment cash grants	10%	10%	0%

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Among these three options, which is your preference?

	Option 1	Option 2	Option 3
Administrative process duration	3 years	1 year	7 years
Legal security	Given in all cases	Not given; corruption possible	Given in some cases
Grid access	Access guaranteed; priority dispatch (no output curtailment)	Access guaranteed; no priority dispatch (output curtailment is likely)	Access guaranteed; priority dispatch (no output curtailment)
Total remuneration	11 $ct/kWh	15 $ct/kWh	11 $ct/kWh
Credit financing	Gov. guaranteed soft loans 1% below market rate	No support	No support
Investment cash grants	0%	30%	0%

- option 1
- option 2
- option 3

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Which other attributes are important for you in wind project development decisions?

Are there support instruments you have missed in the survey that are important for your project development decisions?

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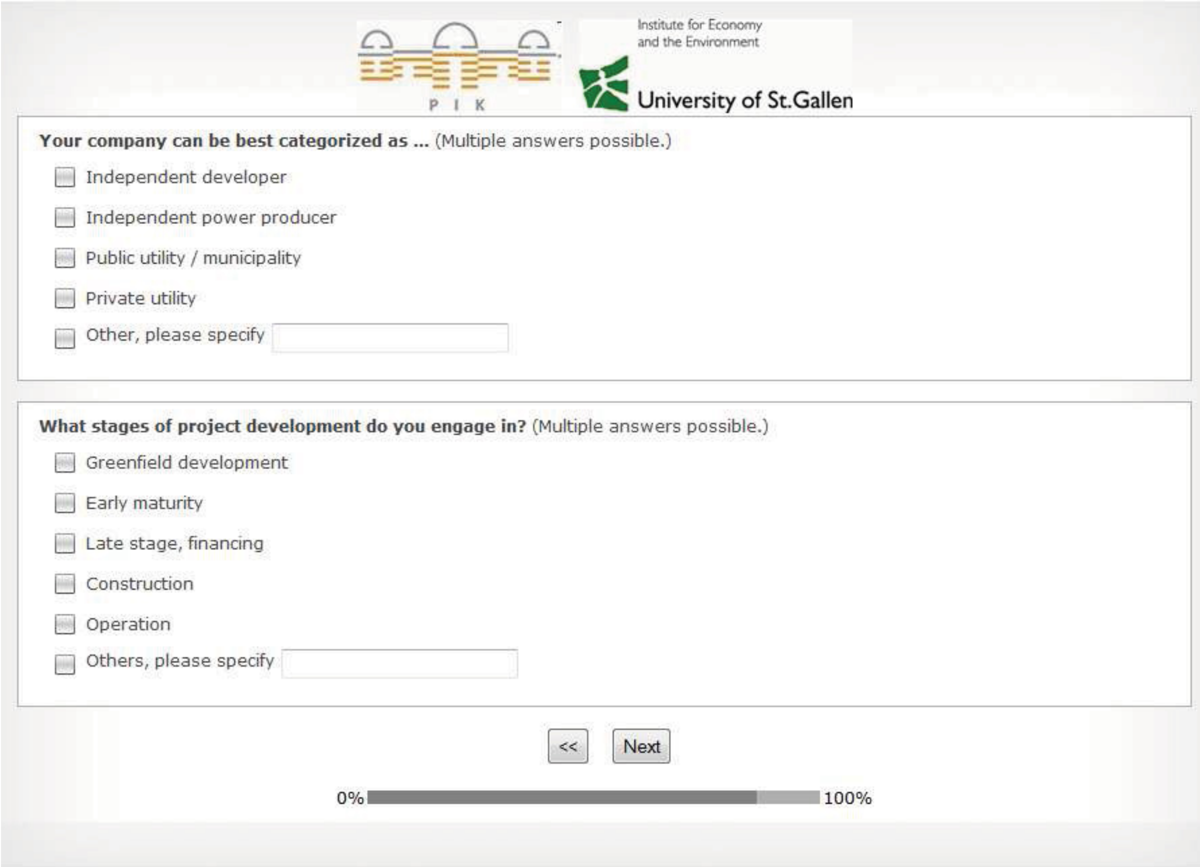

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Your company can be best categorized as ... (Multiple answers possible.)

- Independent developer
- Independent power producer
- Public utility / municipality
- Private utility
- Other, please specify

What stages of project development do you engage in? (Multiple answers possible.)

- Greenfield development
- Early maturity
- Late stage, financing
- Construction
- Operation
- Others, please specify

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How many years of experience in energy project development do you personally have?

Of these, how many years relating to wind energy projects?

How many years of experience in wind energy project development does your company have?

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In which country is your company's headquarter located?

- Austria
- Bulgaria
- Croatia
- Denmark
- France
- Germany
- Great Britain
- Greece
- Italy
- Poland
- Romania
- Slowenia
- Spain
- Sweden
- Turkey
- US, please specify state
- Others, please specify country

In which countries is your company active in wind energy project development? (Multiple answers possible.)

- Austria
- Bulgaria
- Croatia
- Denmark
- France
- Germany
- Great Britain
- Greece
- Italy
- Poland
- Romania
- Slowenia
- Spain
- Sweden
- Turkey
- US, please specify state
- Others, please specify country

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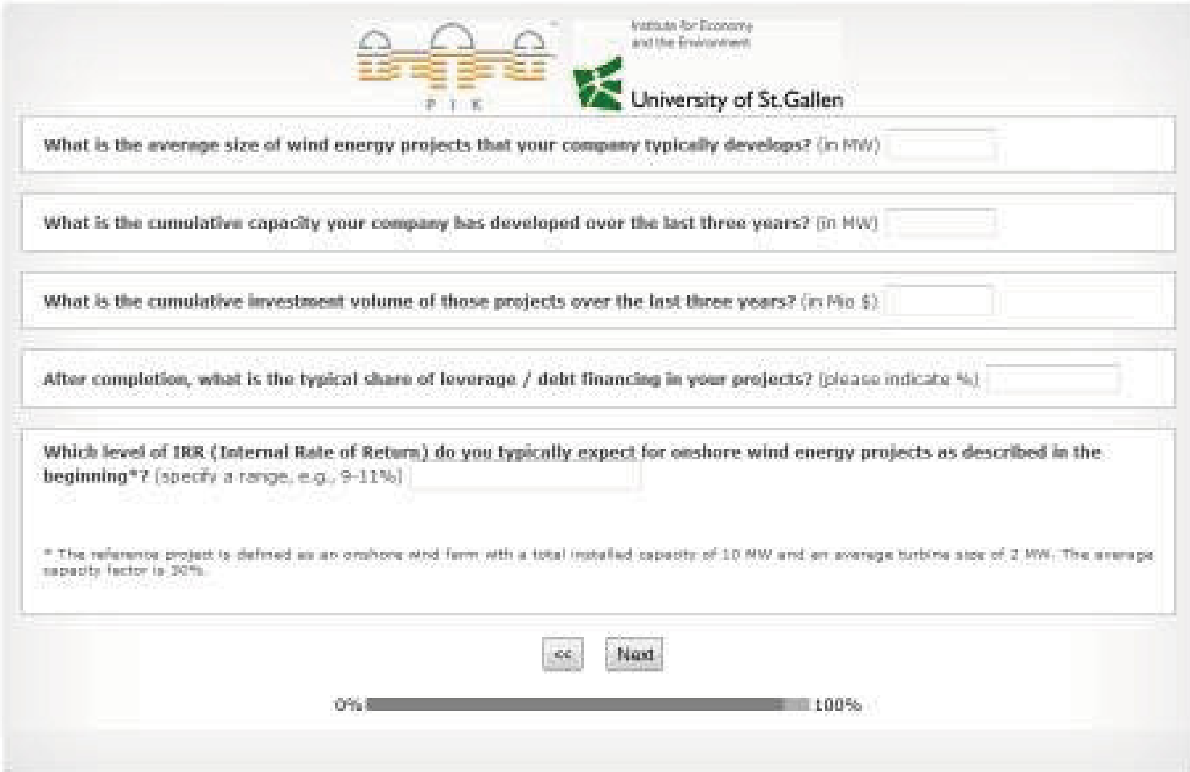

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What is the average size of wind energy projects that your company typically develops? (in MW)

What is the cumulative capacity your company has developed over the last three years? (in MW)

What is the cumulative investment volume of those projects over the last three years? (in Mio $)

After completion, what is the typical share of leverage / debt financing in your projects? (please indicate %)

Which level of IRR (Internal Rate of Return) do you typically expect for onshore wind energy projects as described in the beginning*? (specify a range, e.g., 9-11%)

* The reference project is defined as an onshore wind farm with a total installed capacity of 10 MW and an average turbine size of 2 MW. The average capacity factor is 30%.

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5 Discussion and Conclusion

Many governments have become interested in increasing the use of renewable energies. Achieving objectives regarding renewable power production depends on whether public policy effectively influences the behavior of project developers and investors. There has been substantial policy experimentation and learning over recent years, but how project developers react to certain policy attributes has been a black box so far. This doctoral thesis has opened this black box by conducting two conjoint analyses among European and U.S. solar and wind energy project developers. Conjoint analysis allows partitioning developers' decision-making processes into the underlying preferences for various risk and return attributes and quantifying the importance of these attributes. These insights can help policy-makers to design more cost-effective renewable energy policy measures.

The following section integrates findings from the three previous chapters to answer the five research questions stated in the introduction chapter of this thesis. Section 5.2 describes implications for policy-makers. Section 5.3 outlines the theoretical, methodological and practical contributions of this thesis, and section 5.4 discusses some limitations of the study and the applied method and suggests further research possibilities.

5.1 Summary

The first finding of this doctoral thesis is that risk factors are critical in regard to the deployment of renewable energies and might hinder their deployment even when one would expect a high level of deployment based on the return related factors (level of feed-in tariff, climatic conditions, etc.). The case study analysis of study 1 showed that the implementation of a feed-in tariff is likely to increase a country's installed PV capacities, but how effectively this objective will be reached is mediated by policy risk factors. Spain and Greece provide very favorable return conditions, whereas return conditions are somewhat less favorable in Germany. Thus, looking at the return factors, one would expect a particularly high level of market diffusion in the two Mediterranean countries. This indicates that the level of market diffusion does not increase proportionally to the level of achievable returns, but is – beyond a certain point – very sensitive to investment barriers such as administrative hurdles, grid access and the risk of policy changes. The case study of Spain illustrates the importance of PV policy stability for project developers, and the case study of Greece shows the crucial role of the duration of the permitting processes for PV market deployment.

Second, the fact that policy risk hinders the deployment of renewable energy was confirmed by two conjoint analyses among renewable energy project developers. This approach allows quantifying the importance of different policy risk and return factors. Study 2 investigated five policy attributes: administrative process duration, feed-in tariff level, cap, PV policy changes and feed-in tariff duration. The surveyed PV project developers perceived the duration of the administrative process (26%), followed by the level of the feed-in tariff (24%), as the most important attributes in the decision to invest in a given country. The existence of a cap (19%) and solar energy support policy stability (18%) were of medium importance, and the duration of the feed-in tariff (14%) was of lowest importance. Study 3 investigated administrative process duration, legal security, grid access, total remuneration, credit financing and investment cash grants. The wind energy project developers indicated that, in general, legal security (28%) and remuneration (27%) are of the highest relative importance, followed by the administrative process duration (17%), investment cash grant (11%), grid access (10%) and credit financing (6%). When selecting the most preferred policy scenario, wind energy project developers indicated the highest preference for very short administrative process duration and grid access regulation that guarantee priority dispatch.

The third finding of this thesis is that higher risks need to be compensated with a higher level of support to maintain a country's renewable energy investment attractiveness for project developers. Study 2 estimated these risk premiums for different policy risks. In the case of administrative process duration, for example, the study estimates that for every half-year increase in the duration of the administrative process, PV project developers ask for an increase of the feed-in tariff premium of 3.68 €ct/kWh (all else being equal).

Fourth, in the case of very high risks (e.g., the possibility of corruption) or very low remuneration, many developers apply non-compensatory decision-making rules when evaluating opportunities and very unfavorable attributes are considered as knock-out criteria. Study 3 showed that more than 50% of the wind energy developers see the possibility of corruption, and about 30% see an administrative process duration of 7 years or the lowest remuneration level included in the study (5€ct/kWh respective 7$ct/kWh), as knock-out criteria.

The fifth finding of this thesis is that the effectiveness of certain policy measures depends on the specific policy framework conditions of a given country. Shortening the duration of the administrative process might lead to a strong improvement of the investment climate attractiveness in one country or region, whereas it might have almost no impact in another. In study 3, preference simulations were conducted to estimate the effects of policy measures in three different policy framework contexts on investment preferences of project developers. The hypothetical Southeast (SE-) European base case indicates that a reduction of the administrative process duration yields the highest increase in investment attractiveness. The hypothetical U.S. base case can be strongly improved by introducing better grid access regulations, especially priority dispatch and an increase of the remuneration. In the case of the hypothetical Northwest (NW-) European base case, no policy changes are recommended, because the current relative investment preference is already very high.

The sixth finding of this thesis is that preferences between project developers from different geographic regions with comparable investment environments are quite similar, but there are some differences based on cultural factors, regional barriers for renewable energy project development and support policy familiarity of project developers. Study 3 reveals a generally high similarity in preferences between the NW-, SE-European and U.S. samples. Besides the overall similarity, the investigated regional preferences of developers show three differences. (1) The U.S. developers are generally more in favor of cash grants than European developers who prefer a production-based remuneration. This difference could be caused by policy familiarity of the developers or by higher discount rate of the U.S. compared to European developers (especially to those from NW-Europe). (2) The SE-European developers which are active in countries where corruption is possible evaluate the possibility of corruption as less problematic than the other two developer groups. At the same time the SE-European developers have higher remuneration expectations. The higher acceptability of corruption could result from the fact that many SE-European developers are familiar with this problem and have learned to deal with it, but demand in return a higher remuneration. The possibility of corruption is of great concern to U.S. and NW-European developers and many of them refrain from developing projects under this condition and thus consider the possibility of corruption as a knock-out criterion. (3) The U.S. and SE-European developers state a higher preference for grid access regulations that secure priority dispatch of wind energy than NW-European developers. The latter usually have such provisions and the former experience the lack thereof and thus have higher awareness for the need.

5.2 Implications for energy policy design

Governments can build on the findings of this thesis to design policies that will be more effective in enhancing the development of renewable energy projects and, at the same time, lowering costs for the society.

First, the study confirms that risks are of high importance for project developers and sheds light on which risks are most relevant from their point of view. The relationship between policy developments and risk therefore needs to be considered by policy-makers and careful attention should be given to how policy measures can respond to issues related to project development and financing. Although policy design cannot influence all risks (e.g., fuel price risk, operating and maintenance cost risks) it can significantly contribute to lower specific risk factors. The most important risks that should be addressed by establishing specific regulations are the possibility of corruption, a complex permitting process and grid access uncertainties. In some cases, favorable credit conditions are also of high value. However, governments also need to be aware of the fact that changing rules often may itself lead to investment insecurity, especially if they need to end or down-size support measures. Hence, policy-makers should analyze changes carefully before introducing them. In addition, the study revealed that there are certain risks that work as knock-out criteria for some project developers. This is, for example, the case if corruption is possible or the administrative process duration is very long and unforeseeable.

The second main implication for policy-makers is that they can reduce costs for the deployment of renewable energy sources through a good design of support policies. Policy-makers are thus able to provide an attractive investment climate while at the same time maintaining cost-efficiency. This study gives insights into how project developers trade off different return and risk factors. In particular, policy-makers should be aware that long administrative processes, low legal security, grid access problems and, to a somewhat lesser extent, policy risks related to the existence of a cap and a substantial number of unexpected policy changes, have a cost that will need to be reflected in a higher level of support to attract renewable energy project developers. On the other hand, if these risks can be decreased, the level of support can be lower without a loss of investment attractiveness for the country.

Third, this thesis provides an analysis tool for policy-makers allowing ex ante evaluation of the effectiveness of specific policy measures in a certain policy environment. The study shows that the most effective policy measures depend on the current policy framework and thus such a tool is of high value for effective policy design. In three exemplary preference simulations conducted for wind energy policy measures, the SE-European base case simulation indicates that addressing low legal security and shortening the administrative process are of high value, and the U.S. base case simulation indicates that grid access limitations and low production-based remuneration should be tackled first to increase the investment attractiveness for project developers.

Fourth, this thesis indicates that project developers have overall similar policy preferences in comparable investment environments, but that there are some differences caused by support policy familiarity, regional renewable energy project barriers and cultural factors. If these factors are taken into account, the results of this thesis are transferable to individual countries or other regions with comparable investment environments. Hence, it may not make sense to quickly change an investment cash grant support system to a feed-in tariff system. Further, they should take into account cultural factors like investment discount rate and, as mentioned above, especially address problems that are of primary concern for the development of renewable energy projects in their region.

5.3 Contributions to Research and Practice

This doctoral thesis makes important contributions to the energy policy literature and the energy investment decision literature. The contribution to the energy policy literature is threefold. First, it analyzes policy measures effectiveness by investigating renewable energy project developers' stated preferences instead of revealed data (e.g., installed capacities), unlike many previous studies. Project developers are central market actors in the deployment of renewable energy because they effectively link the regulatory environment and financial incentives to the available investment funds in the market resulting in the production of solar and wind energy capacities. Second, it investigates the effectiveness of specific policy measures, rather than support policy instruments or policy risk as a whole. It applies a consistent risk-return perspective on renewable energy policies, thereby pointing to the two dimensions of investor reaction to such policies. This allows the identification of the specific policy risks that are of the highest importance and their comparison to financial support measures. Third, this study introduces an ex ante evaluation approach to answer questions regarding the effectiveness of certain policy measures, individually or in combinations, in specific investment environments.

The theoretical contribution of this thesis to the energy investment decision literature is the application of the discrete choice theory to investment decision-making of renewable energy project developers. This allows the determination of various parts of the decision-making process and the investigation of the importance of specific factors. The results suggest that the consumer theory approach taken to investigate the behavior of project developers makes sense and provides valuable insights into project developers' preferences. This thesis further contributes to this literature stream by collecting data of project developers making their decisions and hence it investigates their "theory in use" rather than their "espoused theories of action" by surveying developers about past decisions (Lohrke, Holloway et al., 2010b). In doing so, this study avoids validity problems such as post hoc revisionism based on lack of memory, social desirability or the inability to articulate complex decision processes. Third, the investigation of the investment behavior of project developers, who are sometimes early-stage investors, adds to the energy investment decision literature as previous studies mostly restricted their focus to venture capital investors.

The methodological contribution of this doctoral thesis is the introduction of conjoint analysis to the investigation of preferences of project developers to quantitatively examine the value of different regulatory and financial measures. This method is widely used in marketing and more recently also in other research areas. The results of this thesis suggest that this method is very valuable and useful in the field of energy policy design. This method allows dealing with some of the challenges of doing an analysis of revealed preferences in an early-stage growth market, such as the absence of sufficiently long time series and the possibility that ex post analyses might systematically come too late. Given its ability to partition policy framework choices into underlying respondent preferences for specific policy attributes, this conjoint analysis allows disentangling the importance of different policy attributes to explain outcomes such as installed capacities. Also, this method makes it possible to indirectly estimate preferences, which has clear advantages when compared to direct preference inquiries, as the latter may be subject to the distortions of socially desired answers and the lack of memories regarding the exact decision-making process.

This thesis is of high practical relevance to enhance the deployment of renewable energies. Policy design is crucial to enhance renewable energy investments as renewable energy sources are not yet self-sustaining. It is thus of primary importance to integrate the industry sector into the current policy design activities. This thesis is a highly valuable contribution in this regard.

The study is of high relevance for policy-makers, first, by giving insights into preferences of renewable energy project developers. This is of high value for the design of effective support policy measures as developers are central market agents for the deployment of renewable energy. In a market mainly driven by policies – which describes the current renewable energy market – developers decide whether a policy framework is attractive enough to spur development activities. Thus, they effectively link the regulatory environment and financial incentives to the available investment funds in the market by constructing, or deciding not to construct, renewable energy plants. There have been some calls for including the investors' and project developers' perspective, but so far, the scientific community has so far only rarely included this target group in any research project.

Second, this thesis is of high relevance to policy-makers as it identifies and quantifies the most important policy risk and return factors. Prior research recognized the importance of policy risk for the development of renewable energies, but the impact of specific policy risks and their relevance in regard to financial measures had not been analyzed. Understanding the preferences of project developers makes it possible for policy-makers to gauge which measures they need to prioritize to reach specific goals.

Third, the preference analysis extends previous research by showing that a price tag can be attached to specific policy risks. This allows policy-makers to quantify and prioritize the influence of specific policy risks on investment behavior. This thesis shows that accelerating administrative process, removing a cap and increasing policy stability are important ways in which policy-makers can increase their country's attractiveness for renewable energy investors without offering additional financial support. For each of those policy risks, the empirical results provide evidence of the level of risk premium that renewable energy project developers will demand.

Fourth, this study is one of the first attempts to provide an ex ante analysis tool to assess the effect of specific policy measures. So far, research about energy policy effectiveness has mostly taken an ex post case study approach. This thesis' analysis of stated preference data gives evidence about the effect of different policy measures on actions of renewable energy developers. Real-time stated preference data allows simulations of developers' investment likelihood under hypothetical new policy framework conditions with different support measures (attributes) or different degrees (levels) and thus to estimate tomorrow's installed capacity.

The results of this thesis are also relevant for renewable energy project developers themselves as they provide insights into their own decision-making process and allow benchmarking their preferences with industry peers.

Finally, the study is of high significance for society, first by enhancing the transition to a sustainable energy system and, second, by promoting the introduction of renewable energy at a lower cost.

5.4 Limitations and directions for further research

This thesis is, to my knowledge, the first study that empirically investigates the policy preferences of international renewable energy project developers applying choice experiments. As with any piece of research, this study is subject to some limitations that provide further scientific avenues. First, some shortcomings related to the method are outlined, followed by more general aspects.

The main shortcoming of conjoint analysis is its inability to capture the complexity of the market (Wittink, Vriens et al., 1992). Conjoint analysis experiments are limited to a certain number of attributes as otherwise the respondents would be confronted with a task that is much too complex. In addition, there are some real-world factors that shape market shares which conjoint analysis cannot take into account (Orme, 2010a). Such factors include – in the context of this study – length of time of existence of renewable energy support policy, situation of the financial market (credit availability), supply conditions (e.g., silicon shortage), awareness raising of governmental agencies among developers (e.g., at a renewable energy fair), language and social acceptability of the population. Notwithstanding these issues, conjoint analysis assumes that developers are 100% aware of market developments and hold all information on available investment options. In the real world, however, developers have only a limited view of opportunities and conditions. Therefore, the results need to be interpreted carefully.

Another widely-recognized shortcoming of conjoint experiments pertains to the way respondents answer the survey (Huber, Wittink et al., 1992; Orme, Alpert et al., 1997). Respondents have a tendency to overstate, which is due to the facts that they do not actually need to make the investment while filling in the survey and that not all possible attributes and attribute levels of investment decision can be included in the study design. Further, respondents sometimes use simplification strategies to answer difficult full-profile tasks and consider only some of the attributes, which results in exaggerated differences in importance between the most and least important factors. Adaptive choice-based conjoint analysis (ACBC) allows overcoming this shortcoming by identifying “must have” and “unacceptable” attribute levels. Another shortcoming regarding the answering process is that, especially for high-involvement purchases or investments, respondents often use more effort making real-world decisions than for making these decisions in an online conjoint survey (Huber, Wittink et al., 1992).

Future research should explore the possibility of cross-checking this thesis’ findings from stated preferences with revealed preference data to improve the ability to capture the market complexity. The choice data can be calibrated with revealed data by including an exponent (scale factor) and external effects within simulations. As longer time series become available, there will be solid external information (such as existing market share data and investment amount data) which makes such a calibration possible. The willingness-to-accept results could be cross-checked with the "rational" financial evaluation of projects, for example, by means of a discounted cash flow model to explore behavioral biases (e.g., duration versus level of the feed-in tariff). Further, it would be valuable to investigate the possibility of improving the preference modeling by combining stated preference with revealed preference data (Hensher, Louviere et al., 2001) and socio-economic factors (Ben-Akiva and Lerman, 1985).

Future research could also expand on the attributes that were included in the surveys. This study examined policy factors in regard to renewable energy power project development in Europe and the U.S. However, depending on the regional and the research focus, different attributes need to be included in the study and there are additional factors that would be of interest to analyze.

A first extension of my work could relate to the regional focus. Instead of examining preferences of developers active in developed countries in which renewable energy technologies have partly made impressive progress in the recent past, one could analyze preferences of project developers in developing and emergent countries. Many of these countries have recently been undertaking renewable energy oriented reforms to overcome the double challenge of meeting growing energy needs and reducing the share of fossil energy. Despite the widespread adaptation of policy lessons of the developed countries, reform processes are happening very slowly and often have not met expectations. Because of these countries’ specific structures, policy transfer is critical. Such a study would need to include certain region-specific attributes, such as overall political stability, investment costs and currency risk. These aspects have not been included in this thesis because they are sufficiently similar within the geographies under investigation.

A second extension of this thesis could relate to other policy factors. For example, one could investigate the relevance of a nation's legislative commitment to renewable energy and environmental policy from the perspective of project developers. On the one hand, a commitment to renewable energies often goes together with support measures and it is thus likely that such a country provides more attractive investment conditions than other countries. A high environmental commitment, on the other hand, might not necessarily work in favor of project developers. Often, environmental concerns get in the way of renewable energy projects and complicate them. In California, for example, the right of objection in case of environmental concerns is currently one of the biggest issues for renewable energy project developers.

A third extension could relate to other, not policy related, factors. Such factors include market based factors (electricity price, production location and competition), language, country size, personal contacts, natural resource endowment and social acceptance of the new technology. For example, all else being equal, a project developer may consider the fixed cost of starting operations in a large country like Spain more worthwhile than in a small country like Cyprus. Another example is the number of existing renewable power plants in a specific region. The existence of many existing plants might be attractive to developers because it might mean that they can benefit from an existing infrastructure and from regulators who are familiar with administrative and grid access procedures; on the other hand, it could also deter developers as they might fear the competition or worry about insufficient grid capacities. Another possibility is that a high percentage of the total gross state product that is attributable to petroleum and coal manufacturing, i.e., the existence of a strong fossil fuel-based interest group, may have a negative impact on the attractiveness for renewable energy investments (Carley, 2009).

A further limitation of the study is the sample size. Recruiting of professional, real-world decision makers in an early-stage growth market is a key challenge and requires a much larger effort than a survey in more mature markets or with consumer or student samples. In total, 182 project developers responded to the surveys conducted for this thesis. Study 2 was done with 63 European photovoltaic project developers and study 3 with 119 European and U.S. wind energy project developers. This gives a good insight into the perspective of renewable energy project. Nevertheless, further research should aim at validating the findings of this thesis with larger sample sizes.

Future research could also expand on the sample focus. This study analyzed renewable energy project developers. It would be interesting to get insights into preferences of other types of investors (e.g., later-stage project financiers). The project cycle of a large-scale solar PV or wind project consists of different phases, each of which has its own risks (De Jager and Rathmann, 2008). As a consequence, preferences from early-stage investors (who are mostly involved in the planning phase) might be different from those of late-stage investors (who are primarily involved in construction and operation). Grid access, duration of support and administrative process duration might be more important for early than late-stage investors, who in turn may be more concerned with credit and regulatory risk (especially in regard to the financial support schemes).

This study was done under the assumption of rational choice behavior. Further research could explore the degree to which developers are influenced by personal biases or heuristics when evaluating opportunities. Behavioral economics identifies different cognitive biases in investment decisions as heuristics, framing and market inefficiencies (e.g., Tversky and Kahneman, 1974; Thaler, 1994).

5.5 References

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6 Curriculum Vitae

Personal Data

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Education

2007 – 2010: **Doctorate in business studies, focus renewable energy policy**
Institute for Economy and Ecology, University of St.Gallen
Thesis Title: "Effective Renewable Energy Policy: Empirical Insights from Choice Experiments with Project Developers"

2004 – 2007: **Training as a high school teacher High (Höheres Lehramt, Sekundarstufe II) in Geography and French**
University of Fribourg

2004: **Certificate CREATE: Turn your Idea into a Company**
University of Fribourg

2003: **Diploma of Aptitude for Teaching of French Foreign Language (Diplôme d'Aptitude à l' Enseignement du Français Langue Etrangère, DAEFLE)**
University of Fribourg

2001 – 2007: **Diploma (the equivalent of a Masters Degree) in Geography with the minors Economics and Environmental Science/Environmental Economy, French Literature and Linguistics**
University of Fribourg

Teaching Experience

2010: **University of Konstanz**
Lecturer of Bachelor course „Going Renewable“

2008/2009: **University of St. Gallen**
Teaching Assistance:
- Anwendungsprojekt Concentrix Solar (WS 2008, SS 2009)

2008: **University of St.Gallen**
Conception and Realization of Opening Week at the: Sustainable Energy in collaboration with the Institute of Business Education and Educational Management (SS 2008, Start WS 2008)

2007: **University of St. Gallen**
Teaching Assistance:
- Blocked Seminar "Corporate Sustainability", CEMS-MIM (1 week)
- Lecture "Sustainability & Innovation", within the Master (M.A.) in Marketing, Services & Communication Management

2006/2007: **High School, Wohlen (AG)**
Geography teacher in French at, bilingual maturity (French – German), (20%, 1 year)

2005/2006: **Bremgarten (AG)**
French teacher at Secondary School in (about 50%, 1 year)

Other Professional Experience

2010 **Good Energies Chair for Management of Renewable Energies, Institute for Economy and Ecology, University of St.Gallen**
Research associate and project manager of research and consulting projects
Focus: solar energy deployment, effective renewable energy policy design, barriers for sustainable energies

2005 – 2007: **AEE (Agency for Renewable Energies and Energy Efficiency), Zürich**
Project worker

2004 – 2007: **WWF, Zürich**
Creation of the GIS-map for the Final report of the Riverwatch

2002: **Youth hostel Fribourg**
Reception and stand in for the youth hostel manager in Fribourg

2001: **Howeg, Dietikon**
Internship book-keeping

Stays Abroad

2009/2010 **Visiting scholar (15 months)**
Berkeley Round Table for International Economy (BRIE), University of California, Berkeley (10 months)
Department of Human and Community Development, University of California Davis (5 months)

2003/2004: **Exchange year within the diploma studies**
Université de Quebec à Montréal (UQAM), Montreal
Concordia University, Montreal