Investments in Renewable Energy under Uncertainty: The Role of Energy Policy, Project Economics and Investor Cognition

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Bern, December 2017 Yuliya Blondiau

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Abstract

Investments in renewable energy play a key role in achieving global climate goals. Favourable policies have attracted a lot of private capital to solar and wind technologies from a wide range of investors in the last decade. In the meantime, the costs of these technologies have declined impressively. Despite these cost reductions, current investments in solar and wind power across several European countries decreased.

This contradicts theoretical assumptions from a decade ago about renewable energy diffusion, which was expected to increase even without policy support as technology prices went down. In the meantime, the literature on investments in renewable energy lists a number of uncertainties affecting these investments. Such uncertainties include policy and revenue risks as well as investor cognition, i.e. cognitive factors that influence investors' risk perceptions and return expectations. From this perspective, policy phase-outs and frequent changes increase the risks and complexity of investing, which may reinforce routines (path dependence) in investment decision-making.

Drawing from these streams of literature, this thesis investigates how policy, project economics and investor cognition affect investments in renewable energy at advanced stages of diffusion. The first paper analyses the role of deployment policy for solar energy at the near grid-parity stages of diffusion. The second paper examines the financial implications of path dependence in investment decision-making by evaluating expected and realised returns on wind and gas power plants. The third paper investigates why energy investors sometimes prefer to allocate their capital outside their home countries and how cognitive decision modes affect their locations choices.

In summary, this thesis contributes to research on renewable energy investments by investigating the roles and interdependencies between policy, project economics and investor cognition.

Keywords: Renewable Energy, Investment Decisions, Wind, Solar, Energy policy, Cognition, Renewable Energy Diffusion

Zusammenfassung

Investitionen in erneuerbare Energien spielen eine Schlüsselrolle bei der Erreichung globaler Klimaziele. Attraktive Förderungspolitik hat im letzten Jahrzehnt viel privates Kapital für Solar- und Windtechnologien von einer Vielzahl von Investoren angezogen. Gleichzeitig sind die Kosten dieser Technologien stark gesunken. Trotz dieser Entwicklungen sind die Investitionen in Solar- und Windenergie in mehreren europäischen Ländern zurückgegangen.

Dies widerspricht den theoretischen Annahmen von vor einem Jahrzehnt über die Verbreitung erneuerbarer Energien, die mit sinkenden Technologiekosten hätte auch ohne Förderung zunehmen sollen. Gleichzeitig kennt die Forschung einige Unsicherheitsfaktoren, die Investitionsentscheidungen beeinflussen. Dazu gehören politische und finanzielle Risiken sowie die Kognition der Investoren, d.h. kognitive Faktoren, die sich auf Risikowahrnehmung und Renditeerwartung auswirken. So erhöhen häufige politische Richtungswechsel das Risiko und die Komplexität von Investitionen, was bestehende Investitionsroutinen (Pfadabhängigkeit) verstärken kann.

Hierauf aufbauend wird in der vorliegenden Arbeit untersucht, wie sich Politik, Projektwirtschaftlichkeit und Kognition der Investoren auf Investitionen in erneuerbare Energien auswirken. Der erste Artikel analysiert die Rolle der Förderungspolitik für Solaranlagen in einem nahezu netzparitätischen Stadium. Im zweiten Artikel werden die finanziellen Auswirkungen der Pfadabhängigkeit bei Investitionsentscheidungen ermittelt, indem erwartete und realisierte Renditen von Wind- und Gaskraftwerken verglichen werden. Der dritte Artikel untersucht, warum Investoren ihr Kapital teilweise im Ausland anlegen und wie kognitive Entscheidungsmodi ihre Standortwahl beeinflussen.

Zusammenfassend liefert die Arbeit einen Beitrag zur Forschung von Investitionen in erneuerbare Energien, indem sie die Rollen und Interdependenzen zwischen Politik, Projektwirtschaftlichkeit und Kognition der Investoren untersucht.

Schlagworte: Erneuerbare Energien, Investitionsentscheidungen, Wind-, Solar-, Energiepolitik, Kognition, Diffusion erneuerbarer Energien

I. Introductory chapter

1. Motivation

The risks of global warming have been the topic of international discussions for several decades. At the Paris Climate Change Conference in 2015, over 190 countries agreed to address these risks by making efforts to limit the global temperature rise to a maximum of 2 degrees Celsius (2°C) above pre-industrial levels (UNFCCC, 2017). According to recent estimations, in order to limit global warming to 2 degrees, renewable energy share needs to grow from 15% of global primary energy supply to at least 65% by 2040 (OECD/IEA & IRENA, 2017). Investments in renewable energy will play a key role in achieving this goal. These investments have been associated with a number of uncertainties related to their economic competitiveness, policy support mechanisms, and investors' preferences (Huijben & Verbong, 2013; Lüthi & Wüstenhagen, 2012; Siddons et al., 2015).

In order to address the issue of climate change and attract private capital to renewable energy markets, renewable energy support policies were introduced in many countries around the world. These policies contributed to a growth in investments in renewable power generation (REN21, 2017). In 2007, global investments in renewables were at $159 Billion. By 2016, they had reached $242 Billion (see Figure I-1).

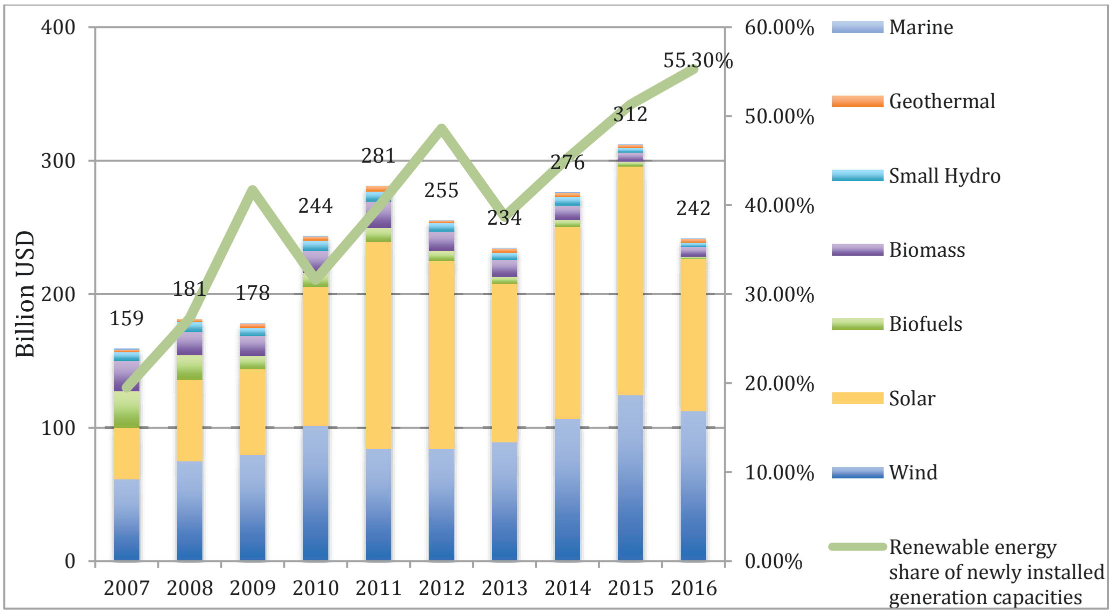

Figure I-1. Global investments in renewable energy, 2007-2016. (FS-UNEP & BNEF, 2017)

Wind and solar energy attracted the most capital and made up 80% of newly installed renewable energy capacity (FS-UNEP & BNEF, 2017; REN21, 2017). It is the investment in these particular technologies that will be examined throughout this dissertation.

Despite an overall upwards trend, financial streams allocated to renewables did not increase continuously. This can be seen in 2016, where investments were lower than in the preceding year (Figure I-1). Nevertheless, the installed capacity was 23% higher than in 2015 (REN21, 2017). More installations with less capital could be financed thanks to decreases in renewable energy costs, which had occurred continuously over the past decades, with the year of 2016 being no exception (FS-UNEP & BNEF, 2017).

In spite of renewable energy cost reductions, around $150 Billion is still spent worldwide on investment in fossil-fuelled power plants (REN21, 2017; Shah et al., 2013). The situation is complicated by existing subsidies for fossil fuels, which are, globally, still two times higher than renewable energy support schemes (IEA, 2016). Even though investments in fossil fuels, such as gas-fired generation, are sometimes explained by the assumed need to provide a balancing backup for the electricity markets, recent research finds that such investments rather intensify the carbon lock-in (Chignell & Gross, 2013).

Recent evaluations of the national climate plans from different countries by the United Nations point out that current commitments can only bring a third of the required emission reductions by 2030 and are likely to lead to a temperature rise of 3 degrees by 2100 (UNEP, 2017). In order to increase investment levels in renewable energy and combat climate change, there is still a lot to be done. This thesis aims to help create a better understanding of the key aspects affecting the investments in solar and wind technologies.

2. Theoretical foundations

2.1 Innovation adoption and diffusion theory

According to Rogers, who published the first edition of his work on innovation diffusions in 1962, the diffusion is a process by which an innovation is communicated among the members of a social system through certain channels, over time (Rogers, 2003[1962]). According to Roger's theory, an innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003[1962]). Since investments in solar and wind technologies are either made by companies that used to invest in other types of power generation before or by companies and individuals that are new to energy markets (Bergek et al., 2013b; Helms et al., 2015; Wuestenhagen & Menichetti, 2012), these technologies are conceptualised as innovation objects in this thesis and investments are conceptualised as innovation adoption decisions.

According to the innovation diffusions theory, as more adopters embrace the innovation, the market share of the new product grows and the diffusion follows an S-shaped curve (Rao & Kishore, 2010; Rogers, 2003[1962]). Different diffusion stages are characterized by different groups of adopters: innovators, early adopters, early majority, late majority and laggards. (Rogers, 2003[1962]).

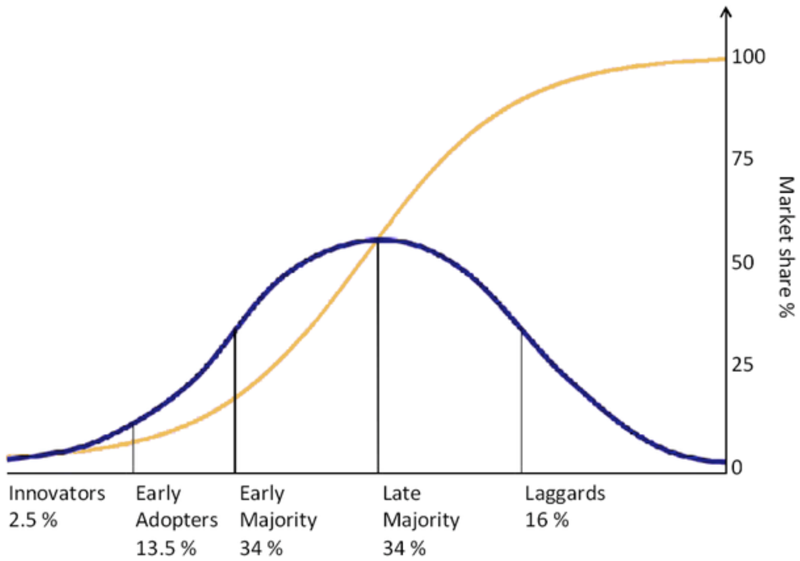

Figure I-2. Innovation adoption (blue) and diffusion curve (yellow), also referred to as S-curve (Rogers (2003[1962])

The Bass innovation diffusion model also sees adopters as the key actors in the innovation diffusion process (Bass, 1969). According to Bass, adopters can be categorized into two groups: innovators and imitators. The speed of innovation adoption and diffusion depends on how innovative the innovators are and whether the rest of the adopters are eager to imitate them (Bass, 1969).

This means that positive attitudes and expectations of adopters towards an innovation are the key to a speedy diffusion process. Recent research suggests that these attitudes and expectations actually change over time and their development process may be reminiscent of a hype cycle curve (Fenn & Raskino, 2008).

Empirical studies on renewable energy diffusion have also highlighted the presence of different adopters at different diffusion stages and categorized these stages into introduction, early growth, takeoff and maturity (Lüthi, 2010; Wüstenhagen et al., 2003).

The movement from one stage to the other is not quick and simple. Moore (2014) suggested that there is a chasm between early adopters and early majority, which may or may not be crossed (Moore, 2014). The idea of a chasm was later explored in a number of studies looking at barriers to renewable energy investments and diffusion (Sonita, 2016; Wiser, 2007).

While an S-curve represents a successful diffusion (Figure I-2) this is not always the case. Innovation theory also describes possible variations of this curve, dependent on the rate of adoption (Rogers, 2003[1962]). If the rate of adoption stagnates, the S-curve may become plateaued. If adoption is discontinued, the diffusion curve may be reversed (Rogers, 2003[1962]). The diffusion process can also follow a series of minor S-curves because of technology discontinuation, due to adopters embracing new versions of a product (Andersson & Jacobsson, 2000).

The S-curve was used as a starting point for describing and analysing the diffusion of renewable energy technologies in a number of studies (Chowdhury et al., 2014; de la Rue du Can et al., 2014; Schilling & Esmundo, 2009). However, in light of recent decline in renewable energy investments in several European countries (REN21, 2017), it is not clear how the diffusion curve for renewables actually looks like.

According to the theory of innovation diffusion, the success of innovation adoption depends on the adopters' characteristics, characteristics of the social system, features of the innovation, communication channels, and time (Rogers, 2003[1962]). Adopters, social systems, and innovation features have received the most attention in the literature on renewable energy investments. Furthermore, policy has become integrated into the discussion about all these factors. I review some of the related contributions in the next sections in more detail.

2.2 Project economics as innovation feature and its interdependency with policy

The innovation features listed by Rogers (1995) were the innovation's relative advantage compared to the old products, its compatibility with the old system, its simplicity of use, its triability and its observability.

Several studies have highlighted that the main advantage of renewable energies such as solar and wind compared to fossil-fuelled generation is the possibility to generate energy without producing greenhouse gas emissions and thereby contribute to climate protection (Jacobson & Delucchi, 2011; Menanteau et al., 2003).

With the time, renewable energies, especially solar photovoltaic energy, became simple to use and to try – one can now lease or buy a solar photovoltaic system even in IKEA, a regular furniture store (Feldman & Margolis, 2014). The observability also improved and triggered peer effects (Bollinger & Gillingham, 2012; Noll et al., 2014).

The compatibility of solar and wind power generation with the energy systems dominated by large-scale centralized energy production was not always obvious. There are studies highlighting the challenges associated with intermittency of electricity production by solar and wind technologies (Gowrisankaran et al., 2016). There are; however, also studies suggesting that these challenges can be addressed with battery storage (Frankel & Wagner, 2017) and demand response (Kamyab et al., 2016).

The costs and revenues, e.g. the project economics of renewable power[1] generation and how it compares to that of fossil-fuelled generation has probably been the most discussed feature of renewable energies in academic literature and by international organizations (Cavallaro & Ciraolo, 2005; Dinica, 2011; Gross et al., 2010; Hagerman et al., 2016; IEA/OECD, 2015; Owen, 2006; Peña et al., 2014; Verbruggen et al., 2010). These studies explored different types of economical evaluation of costs and risk adjusted return, such as average cost of electricity (LCOE) or internal rate of return (IRR). Therefore, the term 'project economics' in this thesis refers to the different evaluations of costs and risk-adjusted returns on the project. A number of recent studies highlighted the improvements in economics of renewable power generation due to cost reductions of renewables (IEA, 2015; IEA_Wind, 2015; Wiesenthal, 2012).

Within this discussion, there are different views on the role of policy for investments in renewable energies. Studies by Murphy (2003) and Grubb (2004) suggested that there is a gap or a "valley of death" between the research and development (R&D) stage and commercialization stage of still-expensive renewable energy technologies (Grubb, 2004; Murphy & Edwards, 2003). These

[1] The term "renewable energy" includes more than just solar and wind technologies. However, since the focus of this thesis is on solar and wind technologies, the terms „renewable energy", "renewables", „renewable energy technologies", „solar and wind technologies" are used interchangeably.

studies categorise policies into push policies supporting the product at R&D stage and market pull policies helping to bridge the abovementioned gap (Grubb, 2004).
Grubb (2004) discusses three types of policy interventions: market engagement programmes moving new technology from the publicly-funded R&D stage to engagement of the private sector; strategic deployment policies "buying-down" the cost of technologies; and barrier removal policies changing regulations, which favour incumbent technologies (Grubb, 2004). Deployment policies, such as feed-in tariffs or renewable energy quota mechanisms, according to Grubb (2004), are only supposed to "buy down" the learning curve, e.g. contribute to costs reductions and bring the technology to the niche market stage.
Indeed, the deployment policies have contributed to increased investments in renewable energies, which caused learning-by-doing effects and cost reductions of renewables (Wand & Leuthold, 2011). Some deployment policies were more effective than others, which was explained by the different levels of perceived risk by investors depending on policy design and the risks attached to it (Dinica, 2006; Kitzing, 2014; Lüthi & Wüstenhagen, 2012; Wüstenhagen & Menichetti, 2012). In particular, long administrative procedures, existence of a cap, and frequent policy changes were found to affect the levels of policy risk (Lüthi & Wüstenhagen, 2012).
Hoppmann (2014) highlights that the policy itself is not an independent construct affecting the market, but it is also affected by market developments such as cost reductions of renewables (Hoppmann et al., 2014). As the costs of renewable energy go down, deployment policies are being increasingly questioned and redesigned (Antonelli & Desideri, 2014; Hoppmann et al., 2014; Peschel, 2014; Pyrgou et al., 2016; Wand & Leuthold, 2011).
As mentioned above, the frequent policy changes cause additional risks for investors. A number of studies therefore suggest that policies need not only to look at costs, but also at risk-adjusted revenues (Gross et al., 2010; Lüthi & Wüstenhagen, 2012; Peña et al., 2014). Thereby, these researchers encourage policy makers to take a holistic perspective on the project economics of renewables, which encompasses more than just costs.
In summary, project economics represents one of the key features of renewable energies defined as an innovation product. Energy policy, and in particular, deployment policies, may contribute to improvement of project economics through enabling cost reductions and may also reduce the attractiveness of project economics via increasing risk levels.

2.3 Adopters' cognition in path-dependent social systems

According to the diffusion theory (Rogers, 2003[1962]), one of the key factors affecting the adoption rate of an innovation is its compatibility with the values, beliefs and past experiences of the social system.

Even though solar and wind technologies have been on the European markets for several decades, investments in renewable energy are still associated with energy systems transformations (Midttun & Piccini, 2017).

Studies that focused on investigating social and technological systems looked at this transformative aspect in more detail and integrated a number of system elements in their research within the categories of actors, networks, and institutions (Bergek et al., 2008; Jacobsson & Bergek, 2004). Systems and their individual elements may be affected by path dependence, a tendency of individuals to make decisions based on past events and established routines (Alexander, 2001; Arthur, 1994; Pierson, 2000; Sydow et al., 2009; Wuestenhagen & Menichetti, 2012; Wüstenhagen & Menichetti, 2012).

As a result of path-dependent development of social systems, these systems may be locked in to a set of established technologies, due to a number of actors continuing to prefer these technologies to new ones (Jacobsson & Johnson, 2000; Wüstenhagen & Menichetti, 2012). However, within the same systems, actors may pursue different goals, which may or may not align depending on the functioning of the networks between actors and the institutions affecting them (Bergek et al., 2008).

In fact, individuals forming the social system, or innovation adopters, from the diffusion theory perspective, are the key actors that may or may not trigger more investments in renewable energies. Therefore, the technology adopters' characteristics have received a lot of attention in the literature on energy investments. A number of contributions in this field focused on investigating investor diversity, investors preferences, decision-making and risk perceptions (Bergek et al., 2013a; Bergek et al., 2013b; Hockerts & Wustenhagen, 2010; Masini & Menichetti, 2012; Masini & Menichetti, 2013; Wuestenhagen & Menichetti, 2012). This stream of literature illustrated the diversity in investor types that joined the electricity markets via investments in ownership of solar and wind energy generation and the importance of both financial and cognitive factors in their investment decisions (Bergek et al., 2013b; Helms et al., 2015).

While solar and wind energy markets in several European countries saw an inflow of new investor types, traditional utilities that were experienced in operating large-scale fossil-fuelled power plants often continued investing in fossil-fuelled production instead of embracing the new technology (IEA, 2017). These types of companies faced a number of new challenges (Castaneda et al., 2017; Richter, 2012, 2013; Shah et al., 2013) and often demonstrated rigidity with regard to adoption of solar and wind technologies (Nisar et al., 2013; Shah et al., 2013). The reasons for this rigidity may be associated with path dependence (Koch et al., 2009) and institutionalised beliefs embedded in an investor's organisational identity (Ford & Schellenberg, 1982; Suchman, 1995).

Drawing from a number of contributions on investments in renewable energy, Wüstenhagen and Menichetti (2012) developed a model of energy policy and investment. This model focused on actors taking investment decisions and their cognition. It highlighted that the actual risk-return investment profiles may differ from perceived risk-return profiles because of the moderating aspect of investor cognition. Investor cognition or cognitive aspects are, in turn, affected by previous experiences and investor type, as well as by energy policy.

A number of further contributions on renewable energy investments highlighted the role of non-financial factors affecting investment decisions (Chassot et al., 2014; Masini & Menichetti, 2012; Masini & Menichetti, 2013) and the role of implicit cognition (Chassot et al., 2015).

Dual process theories of choice and decision-making in cognitive psychology (Kahneman, 2011; Weber & Lindemann, 2007; Weber & Johnson, 2009) and management research (Louis & Sutton, 1991), further highlight the importance of implicit cognition by suggesting that "how" decisions are taken may impact "what" kind of decisions are taken. Weber & Lindemann (2007) posit that people use different decision modes (calculation-, recognition- or affect-based modes), which, in turn, shape decision-making outcomes.

2.4 Bridging energy policy, project economics and investor cognition

In summary, prior research identified the importance of project economics in energy investments as well as the importance of investor cognition. Energy policy received a lot of attention in the studies investigating the economics of energy projects as well as in the studies addressing the aspects of investor cognition in energy investments (Masini & Menichetti, 2013; May, 2017; Peña et al., 2014).

Several studies addressed risks associated with energy policy and the perceptions of these risks by various types of investors (Bü er & Wüstenhagen, 2008; Kitzing, 2014; Lüthi & Wüstenhagen, 2012).

There are a number of studies highlighting the importance of energy policy for systems transformation (Chowdhury et al., 2014) and targeting policy-makers as actors that may use the systems' analysis for policy development and implementation (Bergek et al., 2008; Jacobsson & Bergek, 2004, 2006; Jacobsson & Johnson, 2000; Jacobsson & Lauber, 2006). In this context, the question remains, whether policies should still be represented by deployment policies, which, according to the earlier literature (Grubb, 2004) were only assumed to bring technologies to the niche markets.

Drawing back to the framework of product development stages and policies suggested by Grubb (2004) as well as the contributions by Bürer and Wüstenhagen (2009) and Wüstenhagen and Menichetti (2012), this thesis aims to investigate whether there is a role for deployment policies beyond the niche markets, and what kind of barrier removal policies may be useful in the current stage of renewable energy diffusion (see Figure I-3). Furthermore, it looks at how project economics and cognitive influences may impact investments in renewable energy, and whether this impact is independent or intervened with energy policy.

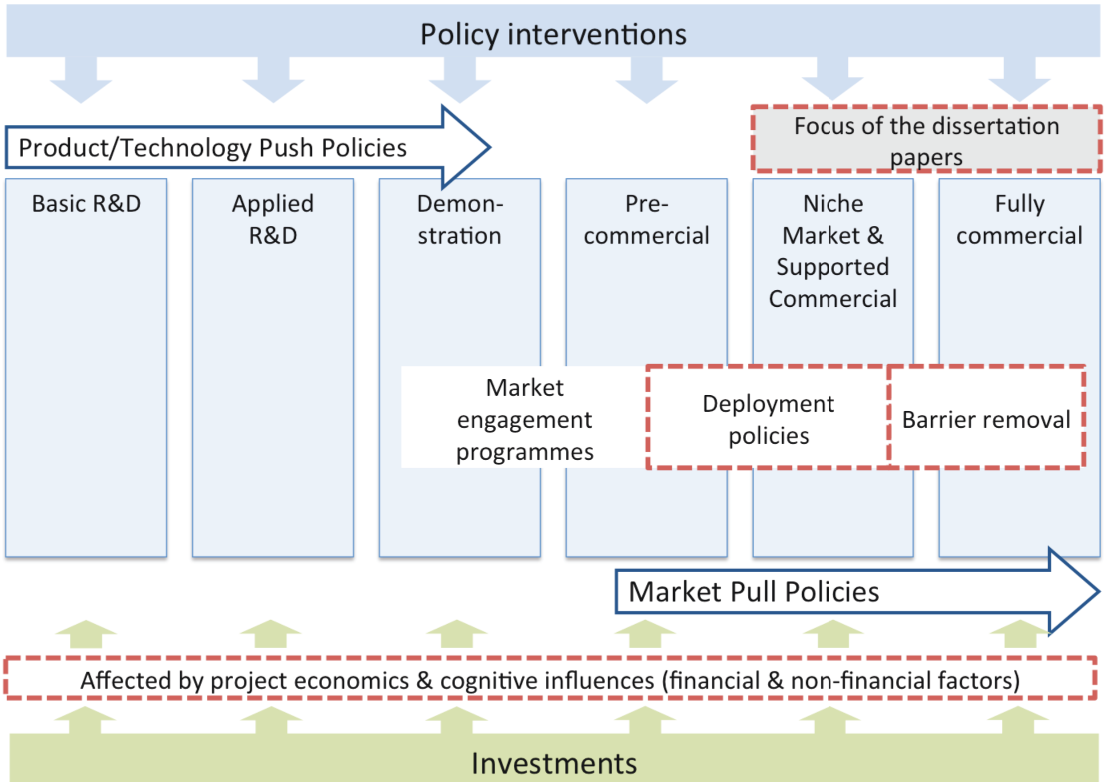

Figure I-3. Theoretical framework of the thesis. Adapted from Grubb (2004), Bürer and Wüstenhagen (2009), Wüstenhagen and Menichetti (2012).

3. Empirical background

3.1 Energy policy in the context of investor diversity and declining costs of renewables

In Europe, energy policy has played a key role in promoting renewable energy investments. The European Union (EU) introduced non-binding targets for electricity production from renewable energy as early as 2001 and set binding targets in 2009. The binding targets addressed renewable energy installations, CO_2 reductions and energy efficiency improvements both at European and individual country levels, to be reached by 2020 (EUR-Lex, 2017). Several EU countries implemented policies supporting renewable energy production even before introduction of the binding EU targets and chose to extend these policies afterwards (Brown, 2013).

From outside the EU, Switzerland also introduced a renewable energy support policy in 2008; albeit one with limitations (SFOE, 2008). They also developed an energy strategy, which was approved by the Swiss population in a referendum in 2017 (SFOE, 2017). This strategy envisions an exit from nuclear power production, an introduction of energy efficiency measures, and renewable electricity production targets of 4.400 GWh by 2020 and 11.400 GWh by 2035, without counting in the hydropower (SFOE, 2017).

Nevertheless, due to recent renewable energy cost reductions, the amount of policy support for renewables around Europe has been decreasing and now the role of policy is being questioned and redefined (Held et al., 2017).

Feed-in tariffs guaranteeing fixed payments for produced electricity from renewable energy sources for an extended period of time were and still remain the most popular support policy for renewables in Europe (CEER, 2017). This policy has been a very successful instrument in spurring on solar energy diffusion in Germany and in Italy: solar installations in Germany grew from about 300 MW in 2002 to 40,85 GW in 2016 and from 6.4 MW to 19.28 GW in Italy during the same time period, bringing these two countries to the top positions of the global country rankings (Fraunhofer, 2017; GSE, 2017; REN21, 2017). Solar energy produced about 7% of the German electricity mix and about 8% of the Italian electricity mix in 2016 (Fraunhofer, 2017; Terna, 2017). This progress can be attributed to investments by a vast range of investor types, most of whom are new to energy markets (e.g. institutional investors, commercial companies, private households and communities), and, to a smaller extent, by traditional energy utilities[2] (Helms et al., 2015; Sommer, 2014).

In the meantime, between 2009 and 2014, solar energy costs went down by at least 75%, leading to discussions about grid parity (Hagerman et al., 2016; Papaefthimiou et al., 2016; Taylor et al., 2015). Despite these cost reductions, the installation growth in solar installations in Germany and in Italy declined (Fraunhofer, 2017; Terna, 2017). The reason for this might be an increased uncertainty among investors associated with renewable energy support policies as these policies become less generous or are phased-out (CEER, 2017). Now, Switzerland, where solar diffusion started to pick up later than in its neighbouring countries, is actually demonstrating higher per-capita installations, despite the fact that only about 31% of the installed solar capacity received feed-in tariffs (Stiftung_KEV, 2016; Swisssolar, 2017).

Putting these developments in the context of theoretical assumptions about technological diffusion of renewables and cost reductions (Grubb, 2004) demonstrates an interesting case for investigating whether and how diffusion of technology relates to its costs, and whether there is a role for a deployment policy in a post grid-parity world (e.g. when the cost of solar electricity is competitive with cost of electricity from the grid). An analysis of interdependencies between feed-in tariffs, solar costs and different investor types, as well as analysis of the resulting business models, may help to answer this question. The cases of Germany, Italy and Switzerland represent an interesting context for studying these interdependencies and allow getting detailed insights into what happens near grid parity. Germany and Italy represent the cases with high pre-grid parity penetration levels of solar PV while Switzerland is a contrasting case, which has recently been outpacing the two in terms of per-capita installations.

[2] In this thesis, the term 'investor' is used to define a private person or a company financing and owning an energy project or part of such a project (e.g. community finance) independently of whichever company manages the operation of the project. Often, financing an energy project includes debt. If a financing institution only provides debt, which the lender pays back, then the lender is considered to be an investor for the purposes of this thesis, and not the bank. A bank or other financing institution is considered to be an investor if it invests in ownership of the power plant in question.

3.2 Path dependence in investment decision-making and its implications

As indicated in the theoretical literature, investments in energy projects can be affected not only by financial, but also by cognitive factors, such as path dependence (Wuestenhagen & Menichetti, 2012). In the context of energy markets, path dependence may prevent companies already experienced in implementing fossil-fuelled power projects from taking a new investment path. Path dependence can be intensified by increased complexity of choices (Koch et al., 2009). Complexity, in turn, may be associated not only with project economics, but also with energy policy. While renewable energy is supported in Europe via feed-in tariffs and green certificates, fossil fuels are also being supported via capacity mechanisms within individual countries and by other types of subsidies from the European Union (EU) (Trilling et al., 2017). About €11.5 billion was spent by EU institutions on gas infrastructure between 2014-2016 (Trilling et al., 2017).

While solar and wind energy markets saw an inflow of new investor types in the past decades, many traditional utilities have refrained from making investments in renewables or continued to invest in fossil-fuelled power projects instead (Helms et al., 2015; Shah et al., 2013). In the case of Switzerland, where the regulations make it challenging to implement new fossil-fuelled projects, energy investors still chose to allocate about 30% of their capital for fossil-fuelled projects abroad, including gas- and coal-fired generation (BNEF, 2015). The data on individual projects suggests that it was mainly traditional utilities that continued to invest in fossil fuels during the European renewable energy boom and this shows the desire of these utilities to stick to their routines rather than take a new path (BNEF, 2015). The implications of such path dependence are not clear, since expected and realised returns on fossil and renewable energy projects were not systematically compared in the past.

3.3 Investor cognition and project location choices

Attracting local private capital is crucial for financing renewable energy projects, particularly in the many countries that are aiming to increase renewable energy share in their electricity mix. However, even when local policies are conducive to renewable energy investments and the economics of local projects look attractive, energy investors sometimes still prefer to allocate their capital for renewable energy projects outside their home countries (Windisch, 2011).

According to the database of Bloomberg New Energy Finance, only 8% of new wind projects financed by Swiss investors were located in Switzerland, with the rest being abroad, particularly in Germany (42%). Only 75 MW of wind projects were implemented in Switzerland at the end of 2016 (suisseéole, 2017). In the meantime, in Germany, a number of prominent investors were also not attracted by local opportunities: German E.On, for instance, has only 12% of its wind portfolio within the country (E.On). This points to a possible tendency for energy markets to perceive grass to be greener on the other side. This also contradicts the literature on international investment streams, which argues that familiarity should breed investment and points to the phenomenon of home bias in investment decisions (Chan et al., 2005; Huberman, 2001).

Previous research addressing the issue of overinvestment abroad by Swiss companies highlighted some of the following arguments used by Swiss investors for explaining their preference for projects abroad: limited wind resources in Switzerland, more secure access to feed-in tariffs abroad, and simpler permitting procedures (Windisch, 2011). However, the available data for the period of 2011-2015 illustrates that the average reported capacity factor characterising wind energy potential has remained the same in Germany and Switzerland over this time (IEA_Wind, 2015). Furthermore, in the reviewed time period, investors in both countries had access to feed-in tariffs. These tariffs were at least twice as high in Switzerland as the tariffs in Germany, in order to compensate for supposedly higher costs. However, the difference between the costs in two countries was not as great as the difference between feed-in tariffs, making the investment option in Switzerland financially more attractive (IEA/OECD, 2015; SFOE, 2016; Vitina et al., 2015). Ultimately, only the issue of permitting procedures was recognised as a serious barrier for projects implementation in Switzerland (Guy-Ecabert & Meyer, 2016; suisseéole, 2016).

Drawing on the theoretical contributions about institutionalised beliefs (Suchman, 1995), one can expect that removing this barrier alone will not necessarily result in more investments in wind power within the country.

Research addressing not only the factors affecting investment decisions, but also the process of decision-making and decision modes (Weber & Lindemann, 2007) may provide valuable insights about managerial cognition with regard to location choices.

4. Focus and objectives

The empirical and theoretical background of this thesis suggest that there are three major factors affecting investments in renewable energy under uncertainty: energy policy, project economics, and investors' cognition.

The term 'energy policy' stands for policies supporting or penalising electricity production from various energy sources. Energy policy has been supporting renewable energies in Europe through feed-in tariffs and trading green certificates, penalising carbon emissions via carbon taxes, but also supporting gas-fired generation via capacity payments or direct subsidies.

The term 'project economics' in this thesis refers to the different forms of economical evaluation of costs and risk-adjusted returns on the project, such as levelised average cost of electricity (LCOE) or internal rate of return (IRR). The economics of the same project may look different to different investor types, based on the differences in their cost of capital and the respective hurdle rates applied to the projects (Helms et al., 2015).

The term 'investor cognition' in this thesis refers to factors that may either affect the investor's perception of specific risks or the evaluation of a project as a whole.

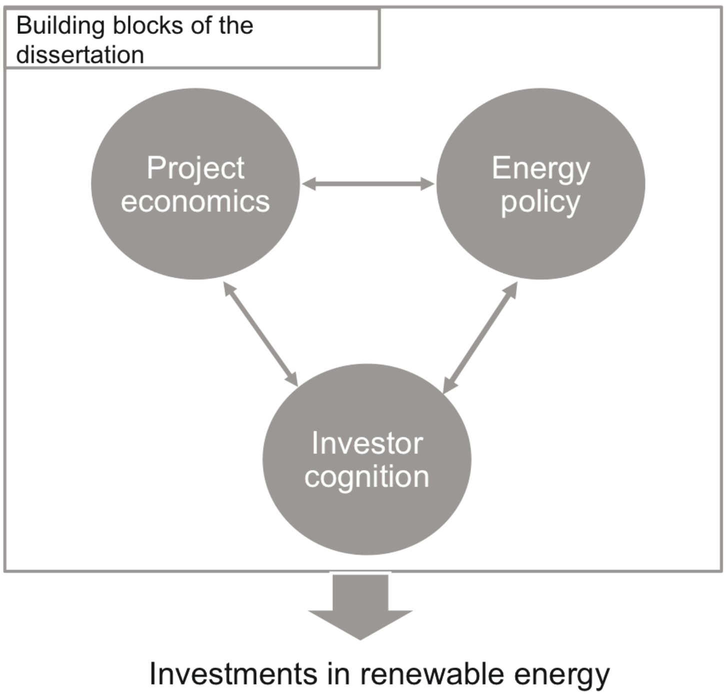

Figure I-4. Conceptual representation of the dissertation focus

The three factors of project economics, energy policy and investor cognition are interconnected and interdependent (Figure I-4). For example, project economics may be positively affected by energy policy if it provides financial support for a project in question, such as feed-in tariffs supporting solar energy. Policy may also affect the project economics in a negative way in case it provides support for competing types of projects or creates a regulatory framework that penalises certain investment types, such as carbon tax policy penalising fossil-fuelled generation. Depending on the type of policy support and its implementation, investors may have different perceptions of the policy risk (Bürer & Wüstenhagen, 2008; Chassot et al., 2014; Lüthi & Wüstenhagen, 2012; Wüstenhagen & Menichetti, 2012). However, it is also possible for investors to have different perceptions of the project economics based on factors other than policy. Investor cognition can, for instance, be affected by previous experiences as well as by familiarity of the investment environment or certain investment types (Helms et al., 2015; Huberman, 2001).

The three papers of this dissertation take into account these three factors affecting renewable energy investments: energy policy, project economics and investor cognition. Geographically, the focus of the three papers are the countries of Germany, Italy and Switzerland.

The first paper focuses on energy policy and looks at the role of feed-in tariffs in a post grid-parity world, based on the cases of solar markets in Switzerland, Italy and Germany. Its objective is to investigate the role of feed-in tariffs for the near- and post-grid parity stages of solar photovoltaics diffusion. In order to address this objective, the paper also integrates the two other dimensions into the analysis. Project economics is evaluated in the three countries via calculation of the levelised costs of solar electricity over an extended period of time. Investor cognition is taken into account to conceptualise the potential business models for different investor types in a post-grid parity world.

The second paper focuses on project economics of wind and gas power plants. Its objective is to investigate the financial implications of path dependence in investment decision-making by evaluating the expected and realised returns on wind and gas power projects. Path dependence is conceptualised as repetition of past investment strategies, particularly leading to a continued focus on fossil-fuelled generation rather than on renewable energy generation. The paper also discusses the role of energy policy in providing guidance for investors in the context of path dependence. As a result, project economics, energy policy and investor cognition are integrated into the analysis of this paper.

The third paper focuses on investor cognition and addresses the issue of overinvestment abroad by Swiss energy investors at the expense of investments at home. Its objective is to find out which decision modes dominate the cognitive processes of investors who are choosing a location for a potential wind project and whether applied decision modes depend on the location discussed. The analysis is based on an experiment conducted with investment decision makers, which included a choice task between two projects. The choice options are defined based on analysis of wind support mechanisms and the actual project economics of wind power plants in the two locations. In this paper, information on project economics and energy policy is used as a basis for investigating investor cognition.

Table I-1 provides an overview of the dissertation papers.

Table I-1. Overview of the dissertation papers

Paper N. and title	**Co-Author**	**Motivation**	**Research question**	**Methodology**	**Conference presentations and publication status**
1. Solar feed-in tariffs in a post-grid parity world: the role of risk, investor diversity and business models	Prof. Dr. Rolf Wüstenhagen	*Empirical:* Many European governments phase-out deployment policies as renewable energy costs go down. In the meantime, investments decrease despite attractive costs. *Theoretical:* Deployment policies were assumed to support technological cost reductions. What is the role of deployment policies in the near-grid parity diffusion stages?	What are the policy implications of PV grid parity?	Cross-case study analysis of three PV markets – Germany, Italy and Switzerland.	Earlier versions presented at: IAEE 2016 International Conference, June 2016, Bergen; SAEE/SCCER CREST Conference, February 2016, Lausanne. Published as an article in *Energy Policy* 106 (2017) 445–456
2. Implications of path dependence in investment decision-making: A cross-case study analysis of returns on gas and wind power projects	n.a.	*Empirical:* A number of traditional utilities continue to invest in fossil fuels despite renewable energy expansion in Europe. *Theoretical:* Increasing returns are antecedents of path dependence. What are the financial implications of path dependence?	What are the financial implications of path dependence in investment decision-making?	Cross-case study analysis of expected and realized financial returns on 20 wind and gas projects realized by Swiss utilities and project developers in Germany, Italy, and Switzerland	Earlier versions presented at: The 8th International Sustainability Transitions Conference (IST), June 2017, Gothenburg; IAEE 2016 International Conference, June 2016, Bergen. Under review in *Technological Forecasting and Social Change*
3. Why is the grass greener on the other side? Decision modes and location choice by wind energy investors	Dr. Emmanuelle Reuter	*Empirical:* Only 8% of wind energy investors from Switzerland allocated their investments at home. *Theoretical:* Financial literature argues that familiarity of local environment should lead to home country bias. Why is it different for energy industry? Previous research highlighted the context- and individual-level factors affecting location choices, while this paper looks at the process of decision-making and decision modes.	What decision modes do investors use for location choice decisions and how these modes affect the choices?	Choice experiment in a natural setting during 12 face-to-face interviews with investment decision-makers representing institutional investors and utilities; verbal protocol analysis (VPA) of the qualitative data, including inductive and deductive (based on decision modes theory) coding	Earlier versions presented at: IAEE 2017 International Conference, Vienna, September 2017; Under review in *Journal of Business Research*

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II. Paper 1. Solar feed-in tariffs in a post-grid parity world: The role of risk, investor diversity and business models[3]

Yuliya Karneyeva[*], Rolf Wüstenhagen[*]

Abstract

Over the past decade, feed-in tariffs have spurred significant deployment of solar photovoltaics in Germany and other countries. With recent cost trends, several countries are approaching retail grid parity. Some policymakers conclude that now is the time to remove feed-in tariffs, as grid parity creates a self-sustaining market, where economically rational investors will invest even in the absence of government incentives. Recent experience in key European solar markets, however, shows that with the advent of grid parity and the reduction of feed-in tariffs, investment in new solar capacity has decreased rather than increased, making it questionable whether low-carbon energy policy targets will be reached. We conduct a cross-case study analysis of three PV markets – Germany, Italy and Switzerland – to investigate the role of feed-in tariffs for the near- and post-grid parity stages of diffusion, accounting for investor diversity and distinguishing between implications for revenue-based and savings-based business models. We find that recent market trends are strongly driven by increased levels of risk, especially policy risk and exposure to revenue risk. We therefore suggest that relatively frugal but stable policy environments may be conducive to further growth of investment in photovoltaics and minimize cost to society.

Keywords
Solar Photovoltaics; Investment; Business Model; Germany, Italy, Switzerland.

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1. Introduction

With costs of photovoltaic modules having declined by 75% between 2009 and 2014 (Taylor et al., 2015), the economics of solar versus conventional power generation have dramatically shifted in recent years. Retail grid parity has been reached in several countries, meaning that consumers can now generate their own electricity from rooftop solar PV at the same cost as purchasing electricity from the grid at retail rates (Fraunhofer, 2015a, 2015b; Pérez et al., 2014; Reichelstein & Yorston, 2013).

What are the policy implications of PV grid parity? Two opposing views can be identified in the energy policy debate: While one camp argues that solar can now "stand on its own two feet"[4] and the lower cost of solar indicates that it is time to remove feed-in tariffs, another camp points to negative investor reactions to previous policy cuts and therefore claims that eliminating incentives now will harm the PV market and negatively affect climate change mitigation targets. The objective of this article is to provide empirical and conceptual clarity to this debate by assessing the factors determining further PV diffusion in the near- and post-grid parity environment and hence investigating what the role of the most common PV policy, feed-in tariffs, may be for the next stages of diffusion, taking investor diversity and newly emerging business models into account.

The research questions addressed in this paper are the following:

1. What is the role of feed-in tariffs for the near- and post-grid parity stages of PV diffusion?
2. How does investor diversity moderate the need for feed-in tariffs after grid parity?
3. How do business models moderate the need for feed-in tariffs after grid parity?

In empirical terms, we review evidence from three interconnected European solar markets (Germany, Italy and Switzerland) to explore how the advent of grid parity changes the diffusion process of photovoltaics. Combining two countries with high pre-grid parity penetration levels of solar PV with a contrasting case, which has recently been outpacing them in terms of per-capita installations, will allow to get detailed insights into what happens near grid parity. A cross-country analysis of

[4] Andrea Leadsom, then Minister of State in the UK Department of Energy and Climate Change, on October 20, 2015. https://www.theguardian.com/environment/2015/oct/20/energy-minister-open-minded-about-uk-solar-subsidy-cuts

these three markets lends itself particularly well to answering our research questions because they are characterized by a diverse investor landscape, the emergence of new business models and varying degrees of policy risk in recent years. This article is, to the best of our knowledge, the first systematic, longitudinal comparison of levelised costs of electricity (LCOE) in these three markets, including analysis of electricity prices, levels of feed-in tariffs, and installations per capita. We also compare the investor landscape in the three countries, calculate profitability for different business models, and quantify the policy risk affecting PV investors. Our aim is to understand how PV investments have changed in recent years in the context of cost reductions and policy changes. In conceptual terms, we build on existing literature and the empirical evidence to develop a framework that puts past experience into a bigger picture and allows for a more nuanced understanding of future scenarios for PV market development.

The remainder of this article is structured as follows. Section 2 provides a short literature review. Section 3 describes the methodology. Section 4 provides results of our country case studies for Germany, Italy and Switzerland. Section 5 presents the cross-case study analysis, and Section 6 concludes the paper with policy implications and an outlook on further research.

2. Literature review

2.1 The role of policy in renewable energy technology diffusion

The diffusion of technology innovation usually follows an S-shaped curve, where market adoption picks up as costs decline (Grubb, 2004; Rao & Kishore, 2010). In the early part of the diffusion curve, technologies tend to be expensive, hence reducing market adoption to innovative customer segments who are willing to pay more and are less risk averse than mainstream customers (Andersson & Jacobsson, 2000; Rogers, 1995; Wüstenhagen et al., 2003). Because it is difficult for innovating firms to capture the benefits of a new product in this early part of market development, there is a case for government intervention to help innovators survive the "technology valley of death" (Grubb, 2004; Murphy & Edwards, 2003). When it comes to environmental innovation, there is a double-externality problem (Rennings, 2000), because it does not only create positive spill-over effects in the market, but also in the non-market environment (e.g. lower emissions), hence creating a second rationale for government intervention.

The classical policy response to the first externality problem is to encourage publicly funded research and development (Margolis & Kammen, 1999; Wiesenthal, 2012). Applied to the case of solar power, this view would suggest that policy support is legitimate to help "buying down the learning curve"[5], but should cease to be in place once grid parity has been achieved (see Figure II-1).

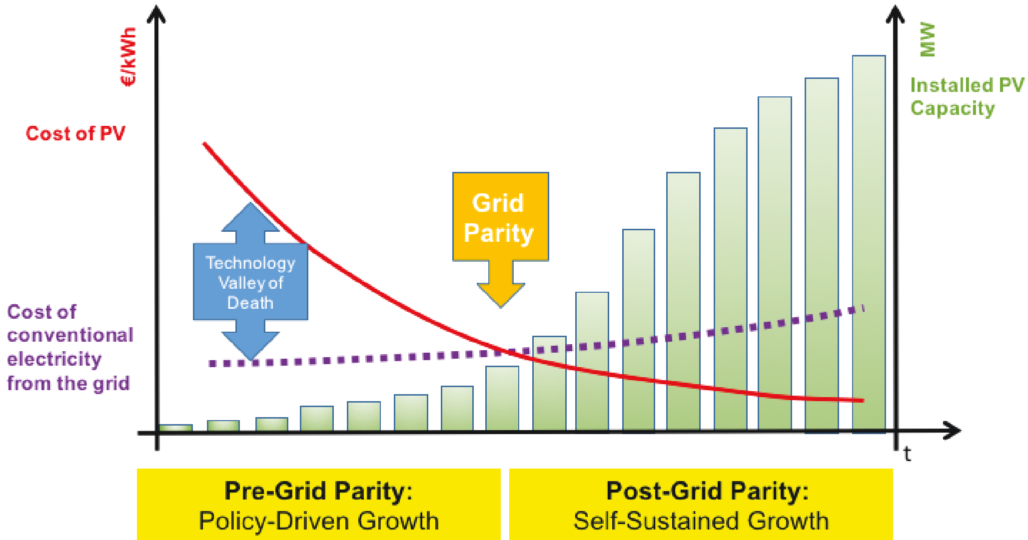

Figure II-1. PV diffusion model (Source: Own illustration adapted from EPIA 2011, Rogers 1995, Grubb 2004)

How does the second externality problem influence the picture? Many economists would argue that the first-best solution to environmental externalities is a Pigouvian tax (Pigou, 1920). However, challenges to the political feasibility of sufficiently high energy and carbon taxes have led to the adoption of dedicated "market-pull policies" such as feed-in tariffs that internalize the external benefit of renewable energies (Bürer & Wüstenhagen, 2009; Gawel et al., 2014). From this perspective, the lack of full internalization of external cost of conventional energy sources provides a rationale for continuing policy support for PV diffusion after grid parity.

2.2 The future of feed-in tariffs

As pointed out in the introduction, there are currently two contrasting views on whether feed-in tariffs will (or should) have a future after grid parity has been reached.

[5] This expression is widely used in the literature on government policies to support technological innovation (Ogden et al., 2004; Vos, 2015).

FIT-skeptics express discomfort with policy cost and claim that it lacks incentives for investors to generate RE when it's needed the most. As for the first argument, the cost of refinancing feed-in tariffs is perceived to be a burden to electricity consumers (Frondel et al., 2008; Frondel et al., 2010), which at some point may exceed consumers' willingness-to-pay (Andor et al., 2016) or the inherent value created by FIT-supported RE generation, e.g. through the merit order effect (Ciarreta et al., 2014). While it is difficult to quantify policy cost and benefit, concerns of overburdening consumers resonate with many policymakers, and in combination with critical design issues and an economic downturn can lead to the collapse of support systems, as evidenced in the Spanish case (Pyrgou et al., 2016). As for the second argument, classical FITs shield investors completely from revenue risk, which eliminates the incentive to generate electricity when it is most needed. While this feature has been helpful in kick-starting investment in capital-intensive low-carbon technologies (Dinica, 2006; Helms et al., 2015; Hirth & Steckel, 2016; Kitzing, 2014),[6] the resulting risk has to be borne by some counterparty in the market, such as conventional producers or the grid operator (Gross et al., 2010), which may become a problem when higher levels of RE penetration are reached (Avril et al., 2012). Solutions brought forward include capping or eliminating feed-in tariffs, or replacing them with quota or auction systems which show desirable characteristics in economic models (Andor et al., 2016), but may or may not deliver on capacity targets (Butler & Neuhoff, 2008; Jacobsson et al., 2009). An alternative solution to completely moving away from feed-in tariffs are more evolutionary changes in policy design, such as a combination of feed-in premiums with net metering (Ramírez et al., 2017). It has been pointed out that investor reactions to feed-in tariffs changes are moderated by (perceived) policy risk (Lüthi, 2010; Lüthi & Wüstenhagen, 2012). This can work both ways – good policies can help to de-risk investment (De Jager et al., 2008; Hamilton, 2009), but poor policies can increase the "price of policy risk" (Lüthi & Wüstenhagen, 2012) resulting in investors requiring a risk premium and consequently lowering investment levels.

FIT-proponents, in contrast, put forward three main arguments why FIT should remain even after grid parity is reached: External cost, dynamic efficiency and

[6] This argument is even more relevant for non-dispatchable renewables like solar and wind, whose output cannot be adjusted to fluctuations in market demand and who are therefore price takers on the electricity market (Lamont, 2008)

limitations to the concept of grid parity. As for the first argument, several authors point out that the external cost of conventional energy sources is still insufficiently internalized (Owen, 2006), as evidenced by low prices in emissions trading (Jenkins, 2014),fossil fuel subsidies (Merrill et al., 2015) or limited liability of nuclear operators (Zelenika-Zovko & Pearce, 2011). Supporting renewables even beyond grid parity would then be a second-best solution to internalizing the external cost of conventional energy sources, and may reap positive co-benefits (Papaefthimiou et al., 2016)). As for the second point, FIT-proponents disagree with FIT-skeptics on the policy cost argument, by suggesting that the relevant yardstick should be dynamic efficiency of RE policies (Jacobsson & Lauber, 2006), and that solar PV's potential to contribute to deep decarbonization paths (Bataille et al., 2016) warrants a strategic investment by society, even if it looks costly in a short-term perspective. Finally, several authors have pointed out that grid parity in itself is not a static concept: While some countries in some years may have reached grid parity, changes in prices of conventional fuels or decreasing marginal returns of RE deployment may turn the wheel of PV deployment backwards at a later point, thus warranting longer-term policy commitments (Bazilian et al., 2013; Papaefthimiou et al., 2016; Yang, 2010).

2.3 Investor diversity and business models

One of the remarkable features of recent PV market development is the inflow of new investors from outside the traditional electric utility industry, including farmers, private home owners, project developers, commercial roof owners, etc. (Bergek et al., 2013; Wuestenhagen & Menichetti, 2012). The emergence of new entrants is not unusual in the context of disruptive innovation (Aldrich & Fiol, 1994) and is often creating significant challenges for incumbents (Christensen, 2013). For policy makers, who can be expected to be interested in outcomes rather than the interest of incumbent firms, new entrants might represent an opportunity to accelerate the transition to low-carbon technologies (Hockerts & Wustenhagen, 2010). When it comes to assessing policy effectiveness, it is important to be mindful that investor diversity implies that different segments of the investment community have heterogeneous preferences with regard to risk and return (Helms et al., 2015). Some investors have high capital cost – for example publicly listed utilities – and will therefore be inclined to look for market opportunities providing high returns, while other investors – for example pension funds – might be more interested in lower risk even if this means accepting lower returns (Donovan & Corbishley, 2016). While a wide-spread view of grid parity is that it greatly improves the returns of PV investment, a more nuanced view reminds us that what determines investment decisions is not just returns, but risk-adjusted returns, which can for example be negatively affected by increasing policy risk or increasing exposure to revenue risk. Changes to the risk-return profile of PV investments may lead to changes in the investor mix.

A final element in understanding the diffusion of solar PV pre-, near- and post-grid parity is the observation that different PV business models are exposed differently to risk. While under the traditional *revenue-based business model*, PV plants have been looked at as any other power generation project, producing electricity and selling into the wholesale market, the advent of retail grid-parity has led to the emergence of *savings-based business models*, under which a significant share of the project's returns do not depend on selling the electricity to a third party but on substituting power purchases on site (Schleicher-Tappeser, 2012). In the revenue-based business model, feed-in tariffs have led to guaranteed returns, but projects are exposed to policy risk. The savings-based business model, in contrast, can be self-sustaining even in the absence of feed-in tariffs. However, unless it is combined with distributed storage, its profitability crucially depends on the extent to which a given project allows its owner to self-consume the electricity on site (Bost et al., 2011). On one end of the spectrum, a commercial roof owner whose electricity demand profile shows strong overlap with the typical PV production curve – such as the case of greenhouses in Sicily presented in Squatrito et al. (2014) or relatively small installations on multi-family houses (Konersmann & Meier, 2015; Squatrito et al., 2014) – will allow for a high share of self-consumption. On the other end of the spectrum, a utility-scale greenfield PV project does not offer any potential for self-consumption. Other types of projects can be placed alongside this spectrum, and hence are exposed to different levels of policy and revenue risk.

2.4 Summary: feed-in tariffs, risk and investor heterogeneity

Figure II-2 assembles the elements discussed in our literature review. On one dimension, potential investors in PV differ with regard to their cost of capital, which reflects their expected risk-adjusted returns. On the other dimension, PV projects differ with regard to their ability to use the electricity on site (self-consumption). If there is high simultaneity of on-site power demand with the PV production curve, savings-based business models open an avenue to profitability without feed-in tariffs. On the other hand, if there is little or no opportunity for self-consumption, revenue-based business models depend on the government (e.g. under a feed-in tariff) or some other long-term counterparty (e.g. under a power purchase agreement or PPA) to provide stable returns. Combining these two dimensions, it becomes evident that exposure to feed-in tariff cuts increases from the lower left to the upper right part of the diagram. The curved lines in the diagram indicate investments of similar exposure to feed-in tariff risk. As governments cut feed-in tariffs, they will increasingly move down those lines, resulting in lower amounts of capital invested in PV.

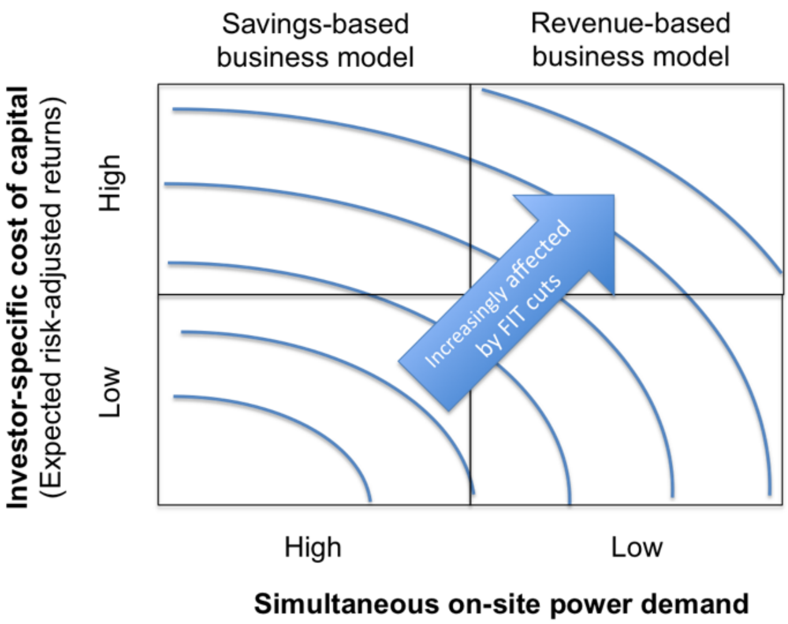

Figure II-2. Conceptual model of the relationship between feed-in tariff cuts and PV investments.

3. Methodology and data

The main objective of this paper is to evaluate how policy's role changes along the stages of solar PV diffusion and to find out what the role of the most common PV policy, feed-in tariffs is for the near grid parity and post-grid parity stages of diffusion. In order to fulfill this objective, we conducted a comparative case study analysis of Germany, Italy and Switzerland. We consciously combine two countries with high historic (pre-grid parity) levels of PV diffusion with a contrasting case. In Switzerland, PV growth has started later, but recent per-capita installations are higher than those in Germany and Italy. All three markets are characterized by investor diversity and the emergence of new business models. Also, our selection of cases allows to observe varying degrees of policy risk over time.

First, we conceptualize the main investor types that could allocate capital to the PV sector and their respective business models that could be affected by FIT policies. We suggest that it is helpful to distinguish two main business models in the PV sector: the ones focusing on revenues from electricity sales to a third party (revenue-based) and the ones focusing on reducing the PV system owner's electricity bill (savings-based). Further, we empirically explore the role of different investor types and the factors affecting installation levels in the three countries by working with the following data: installation volumes, average feed-in tariff levels, levelised cost of electricity generated by PV, electricity prices, investor landscape. To compare the three countries on equal standards, we construct our own investor categorization; calculate LCOE based on the actual PV productivity in the three given countries, and compare LCOE to electricity prices of different consumer segments as well as to FITs in the three countries.

A detailed overview of data sources is provided in tables II-1 and II-2 below.

Table II-1 Data sources for annual installation volumes, average feed-in tariffs, electricity prices.

Variable	Data Sources	Remarks
Average feed-in tariff levels	Italy: GSE, Italian Market Operator (GSE 2015) Germany: BMWi, Federal Ministry for Economic Affairs and Energy (BMWi 2015) Switzerland: Swissgrid (Swissgrid 2015)	Since feed-in tariffs differ depending on the size of installation, the feed-in tariff levels were averaged for this analysis.
Installation volumes	IEA national survey reports for each of the three countries (IEA PVPS 2016).	
Electricity prices	Italy, Germany: (Eurostat 2016) Switzerland: (ElCom 2016)	The typical household was defined as a household consuming between 2500 kWh and 5000 kWh per year in Italy and Germany (based on Eurostat assumptions); in the case of Switzerland, a typical household was defined as a household consuming 4500 kWh per year based on the assumptions of ElCom. With regard to industry, for Italy and Germany it was defined as consumption between 500 MWh and 2000 MWh p.a.; in the case of Switzerland – consumption over 500 MWh but less than 1500 MWh p.a.

Table II-2 Variables included in calculation of PV LCOE and data sources

Variable	Data Source	Remarks
Turnkey system prices	Annual National Survey Reports of PV Power Applications (IEA 2015)	
Operation and Management costs (O&M)	Estimated as 2% of the specified turnkey prices based on Jäger-Waldau (2013);	Annual O&M were multiplied by 20, since 20 is the typical expected lifetime of a PV plant envisioned by FIT support schemes
Electricity produced over the lifetime	Productivity of the PV plants in each of the three countries in 2014: IEA national survey reports for each of the three countries	Estimated based on productivity of the PV plants in each of the three countries in 2014. In order to do that, full load hours of existing installations were calculated by dividing the solar electricity production volumes in 2014 by the total amount of installations less half of the new 2014 installations. This part of 2014 installations was subtracted in order to avoid underestimation of actual full-load hours for countries with high capacity growth in the given year. The resulting full load hours for Italy, Germany and Switzerland were 1211.67, 939.60 and 935.83 respectively.
Discount rate	Base rate is estimated at 3%, as suggested by Dharshing (2017). To reflect investor diversity and the current low-interest rate environment in the three countries, we complemented this base case with scenarios applying discount rates of 0% and 6% .	Germany and Italy are part of the Eurozone, and the European Central Bank's interest rate at the time of writing this manuscript is at 0.0%. The Swiss National Bank's interest rate is negative (at -0.73%), a phenomenon that has received little attention in the Energy Policy literature so far.

While most of the data presented in the case studies is drawn from publicly available sources in the respective national languages, proprietary data on Swiss investors has been obtained from Swissgrid, the Swiss transmission system operator (TSO) that registers all applications for feed-in tariffs. As for Germany, we were granted access to a proprietary investor database by Trend:research. In Italy, comprehensive data is publicly available from Gestore Servizi Energetici (GSE), a subsidiary of the Ministry of Economy and Finance, and from the Italian Regulatory Authority for Electricity Gas and Water (AEEG).

The LCOE levels were calculated using the following formula: capital expenditure for solar PV system cost plus operation and maintenance (O&M) expenses divided by the electricity produced over the lifetime. We applied a discount rate of three per cent in our base-case calculation of LCOE. To reflect investor diversity and the current low-interest rate environment in the three countries, we complemented this base case with scenarios applying discount rates of zero[7] and six per cent.

*Profitability***.** Having information about investor segments, FITs, LCOE, we could calculate a profitability proxy for different investor types. We calculate the profitability proxy for:

- Savings-oriented investors as a measure of a) the difference between LCOE and retail electricity price for residential PV installations; b) the difference between LCOE and electricity price for industry;
- Revenue-oriented investors as a measure of the difference between FIT and LCOE.

Risk evaluation. To include the effect of risk in our analysis, we calculated a proxy for country-level risk for each year. In light of the high practical relevance of policy risk in the context of renewable energy investment, there is a surprising scarcity of empirical academic work aimed at comparative quantification of policy risk. Investors often rely on their own pragmatic assessments or on general country indices provided by rating agencies and consultancies, such as the Political Risk Index by PRS Group[8], or credit ratings by S&P, Moody's and Fitch. With specific regard to renewable energy, E&Y constructs a "country attractiveness index", which, however, only shows aggregate country rankings without publicly disclosing the underlying datasets or weightings used.[9] In the academic literature, risk for investors in solar PV was defined and quantified by Lüthi & Wüstenhagen's (2012) conceptualization of the "price of policy risk", which was based on a survey among European investors. They identified the following risks associated with policy: presence of a cap limiting the supported PV capacity (either no cap, or cap to be reached in 1 year or 4 years, respectively), duration of administrative process in months (from 1 to 24 months), duration of feed-in tariff (15 to 25 years), and significant unexpected policy changes in the last 5 years (a change was considered significant if it led to more than 15% feed-in tariff reduction).

[7] Germany and Italy are part of the Eurozone, and the European Central Bank's interest rate at the time of writing this manuscript is at 0.0%. The Swiss National Bank's interest rate is negative (at -0.73%), a phenomenon that has received little attention in the Energy Policy literature so far.

[8] https://www.prsgroup.com/category/risk-index

[9] http://www.ey.com/gl/en/industries/power---utilities/ey-renewable-energy-country-attractiveness-index-methodology

In the risk assessment presented in this paper, we apply a modified version of Lüthi and Wüstenhagen's (2012) risk definition to account for specificities in the timing and geographical context of our research. We construct a rating that measures the degree to which a PV investor in any given country and year would discount the nominal feed-in tariff due to policy risk. The rating consists of three additively linked components (Table II-3), each of which ranges from 0 (no risk) to 3 (high risk).

The first component is negative policy changes, defined as follows: no risk (0) if policy remained stable in a given year; low (1) if expected or less than 2 unexpected tariff reductions occurred in a given year; medium (2) if more than 2 unexpected policy changes occurred in a given year; high (3) if retroactive policy changes occurred.

The second component is the existence of a cap. Even in the context of an otherwise stable policy environment, a cap imposes a risk on investors' returns because feed-in tariffs might no longer be available at the time of project completion. We define this as: no risk (0) if there is no cap; low (1) if there is a chance of receiving funding in one year; medium (2) if there is a chance of receiving funding in five years; high (3) if the waiting time is over five years or there is no chance of ever receiving funding due to a cap on feed-in tariffs.

The third component is exposure to revenue risk. This was not explicitly modelled in Lüthi and Wüstenhagen (2012) as back then, feed-in tariffs used to offer a complete hedge against fluctuations in wholesale electricity market prices. In recent years, however, this risk is becoming increasingly relevant, as PV investors are required to trade all or part of their electricity generation on wholesale markets, and this revenue stream can be affected by regulation. We define this component as: no risk (0) if PV investors receive feed-in tariffs for all their output and do not have to trade on the electricity market; low (1) if less than half of solar power generation is subject to volatile electricity prices; medium (2) if more than half of solar power generation is subject to volatile electricity prices; high (3) if the full amount of solar power generation has to be sold on the wholesale market without feed-in tariffs.

Table II-3 Attributes and levels of country risk rating

Attribute	Levels	Operationalization
Negative Policy changes	3 – high risk	Retroactive policy changes
	2 – medium risk	More than 2 unexpected tariff reductions in a given year
	1 – low risk	Expected tariff reductions in a given year (or less than 2 unexpected)
	0 – no risk	Policy remained stable in a given year
Cap / Waiting List	3 – high risk	Waiting time is over 5 years or there is no chance of ever receiving funding due to a cap on feed-in tariffs
	2 – medium risk	There is a chance of receiving funding in less than 5 years
	1 – low risk	There is chance of receiving funding within 1 year
	0 – no risk	There is no cap
Revenue risk	3 – high risk	The full amount of solar power generation has to be sold on the wholesale market without feed-in tariffs
	2 – medium risk	More than half of solar power generation is subject to volatile electricity prices
	1 – low risk	Less than half of solar power generation is subject to volatile electricity prices
	0 – no risk	There is no revenue risk (fully guaranteed revenues through feed-in tariffs)

The resulting country risk rating in our assessment is the sum of risk levels per country in a given year (Figure II-3). It ranges from 0 (no risk) to 9 (high risk), and was validated with national experts.

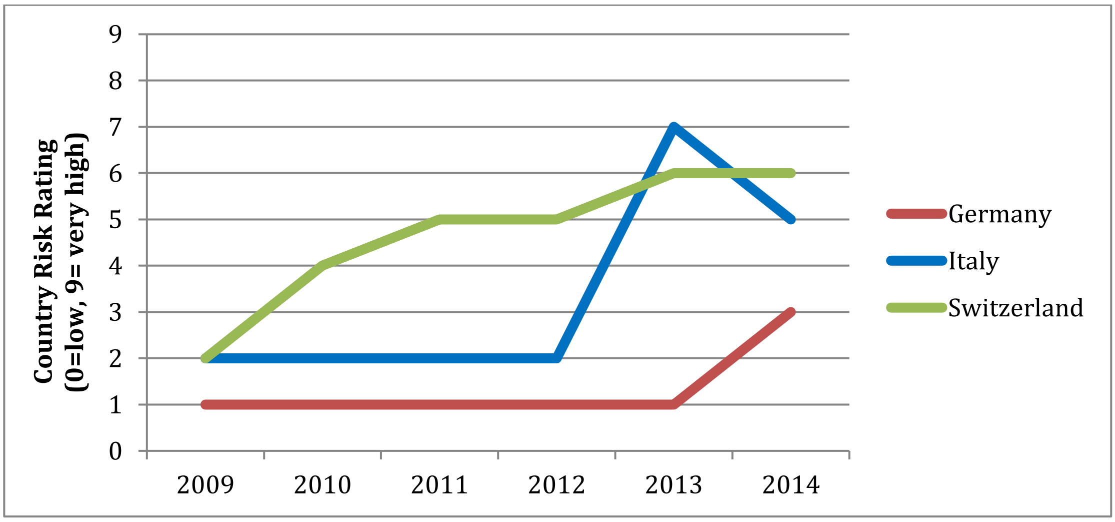

Figure II-3. Results of country risk rating

As an example, in 2013, more than two unexpected policy changes occurred in Italy (risk of policy changes: 2), the cap was introduced and reached within the same year (risk of cap: 3), while the existing installations still received feed-in tariffs, most of the new investors after July 2013 had to expect to trade on the electricity market (revenue risk: 2). Therefore, the resulting risk level is estimated as 7. As another example, two expected feed-in tariff reductions occurred in Switzerland in 2014 (risk of policy changes: 1). However, in the presence of a tight cap and a long waiting list, investors in new projects could not expect to receive feed-in tariffs within the next five years (risk of cap: 3) and almost 70% of installed capacity was not supported through feed-in tariffs and therefore exposed to the risk of fluctuating electricity prices (revenue risk: 3), resulting in an overall risk level of 7.

For an assessment of risk-adjusted profitability of revenue-based business models, we adjusted the expected value of the feed-in tariff based on our risk proxy, resulting in a measure of risk-adjusted revenue that is 0 to 90 % lower than a secure feed-in tariff (10% for each of the 9 points on the 10-point risk scale, assuming there might be unobserved risk factors).

4. Results: country case studies

4.1 Germany

Market development: installed capacities and cost of PV

Currently, Germany is the largest PV market in Europe with 38.5 GW of capacity installed at the end of 2014. These installations produce about 6.9 % of electricity consumed in Germany (Fraunhofer, 2015b). Our calculation shows that levelised costs of solar PV electricity decreased continuously as the number of installations grew. Since about 2010, PV LCOE has been lower than the electricity price for private households in Germany, meaning that retail grid parity has been reached. Moreover, if the electricity price for industry is calculated including taxes and fees, grid parity has also been reached for industrial consumers around 2011-2012 (see figure II-4).

Despite the decrease of LCOE, installation levels dropped sharply in the years 2013-2014. This occurred in a situation when grid parity had already been achieved for households and industry, contradicting the predictions of the standard diffusion model presented in Section 2, and hinting at the influence of risk on investor decision-making.

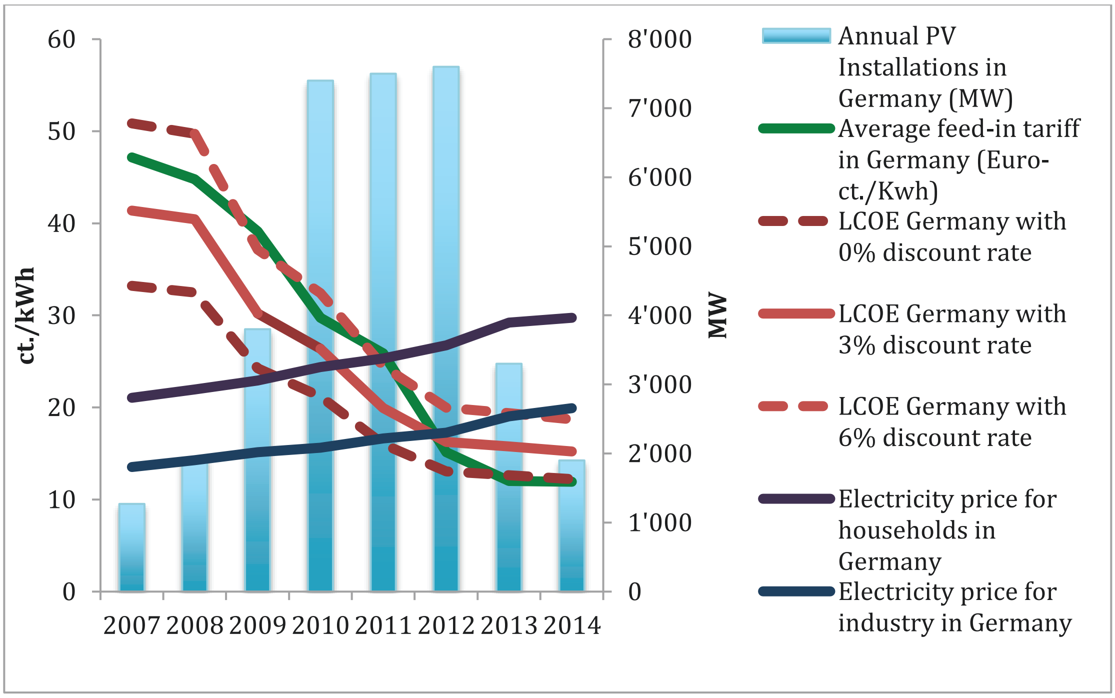

Figure II-4 New PV capacity, average FIT, PV LCOE and electricity prices in Germany by year

Policy and risk

Germany started introducing renewable energy policies earlier than most other countries, providing a low risk environment for investors (Mitchell et al., 2006; Wüstenhagen & Bilharz, 2006). Under the Renewable Energy Act of 2000, feed-in tariffs aimed at covering the electricity generation cost of PV are guaranteed for 20 years (BMWi, 2000). The compensation for new installations was reduced at an annual degression rate of 5%. As the amount of installations exceeded expectations, the EEG was repeatedly amended to increase the degression rate (BMWi, 2015). Prior to 2014, changes to the initial tariff occured in a rather predictable manner, which is why the overall risk level on our scale is only 1 for those years.

New policies started exposing German PV investors to revenue risk. For example, under the 2014 EEG amendment, new installations above 500kW must participate in the direct marketing scheme, which for these larger plants essentially marked a move from fixed feed-in tariffs to sliding feed-in premiums paid on top of wholesale market prices. Since 2016 this applies to installations above 100 kW (BMWi, 2015). Another market integration measure required that starting from 2014, solar PV projects can receive feed-in tariffs only for a share of 90% of the total electricity fed into the grid, with the remaining 10% to be sold at wholesale market prices. Uncertainty for PV investors has increased through the introduction of a target corridor for annual PV installations of 2'400-2'600 MW per year, and an absolute cap once 52 Gigawatts of PV capacity will be reached. Overall, these policy changes and the increase in revenue risk led to an increase in our German risk rating from level 1 to level 3 in 2014 and 2015.

The PV investor landscape and emerging post-grid parity business models

The diffusion of PV was accompanied by a changing investor landscape. Utilities, which used to have the largest share of the electricity market, only own a marginal segment of installed PV capacity in Germany (see figure II-5). This may have different reasons, for example a perceived lack of capabilities of large utilities to deal with small distributed solar PV projects. On the other hand, new types of investors, such as farmers and institutional investors, which include, for instance, insurance companies, pension funds as well as financial institutions, play an important role in solar PV diffusion (Trend:research, 2013). While grid parity means an increase in solar PV competitiveness for all market participants, citizens and retail investors benefit from it the most, since their consumption patterns and the small size of installations suggest that these investors may opt for savings-based business models even if they cannot benefit from selling electricity to the grid. According to SolarPower Europe, over 30% of solar electricity produced in Germany in 2014 was consumed by its producers. On the contrary, large investors, whether they are risk-sensitive institutional investors or risk-taking utilities, tend to profit rather from electricity sales than from savings, meaning that grid parity does not yet mean competitiveness in the perception of these investor groups.

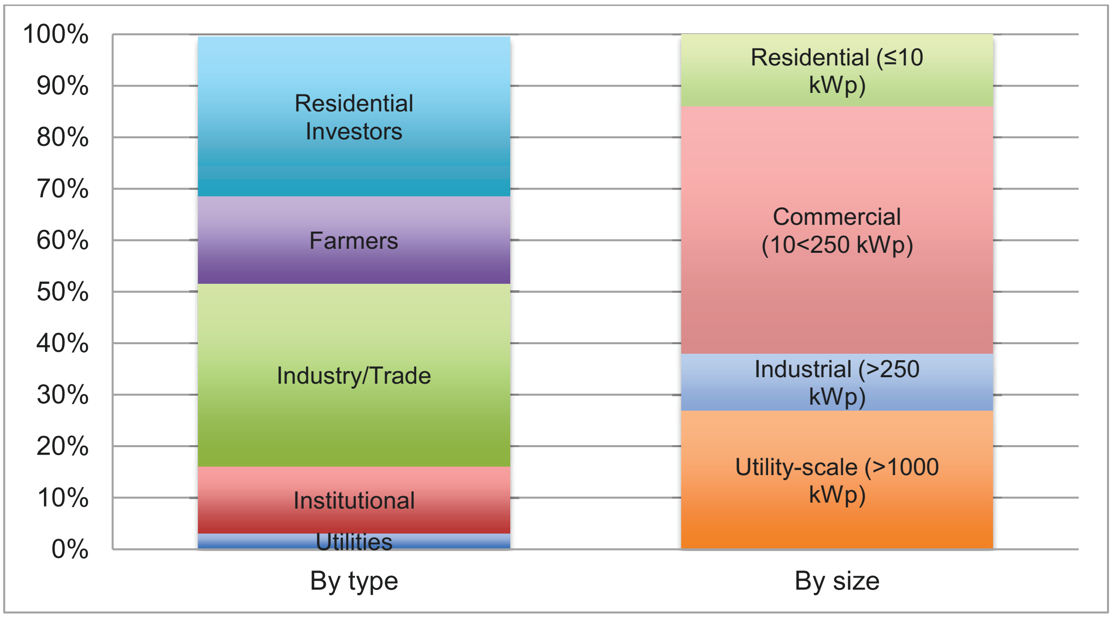

Figure II-5 Investor types and types of PV installations in Germany. Sources: trend:research, 2013; Solar Power Europe, 2015

In terms of project size, commercial and utility-scale installations account for more than 80% of installed capacity. Only a small share of these large installations lend themselves to self-consumption and are thus more exposed to feed-in tariff changes. Even though 30% of produced PV electricity was self-consumed in Germany, its expansion potential might be limited in the absence of distributed storage (Bost et al., 2011).

4.2 Italy

Market development: installed capacities and cost of PV

While the costs of Italian PV installations are similar to the ones in Germany and higher irradiation is more conducive for solar energy diffusion, Italian solar market development has been less consistent than in Germany. Around 2011, Italy was among the top PV installers in the world. On the other hand, an unstable regulatory environment, which included retrospective policy changes, created a pronounced boom-bust cycle in the diffusion curve (see figure II-6).

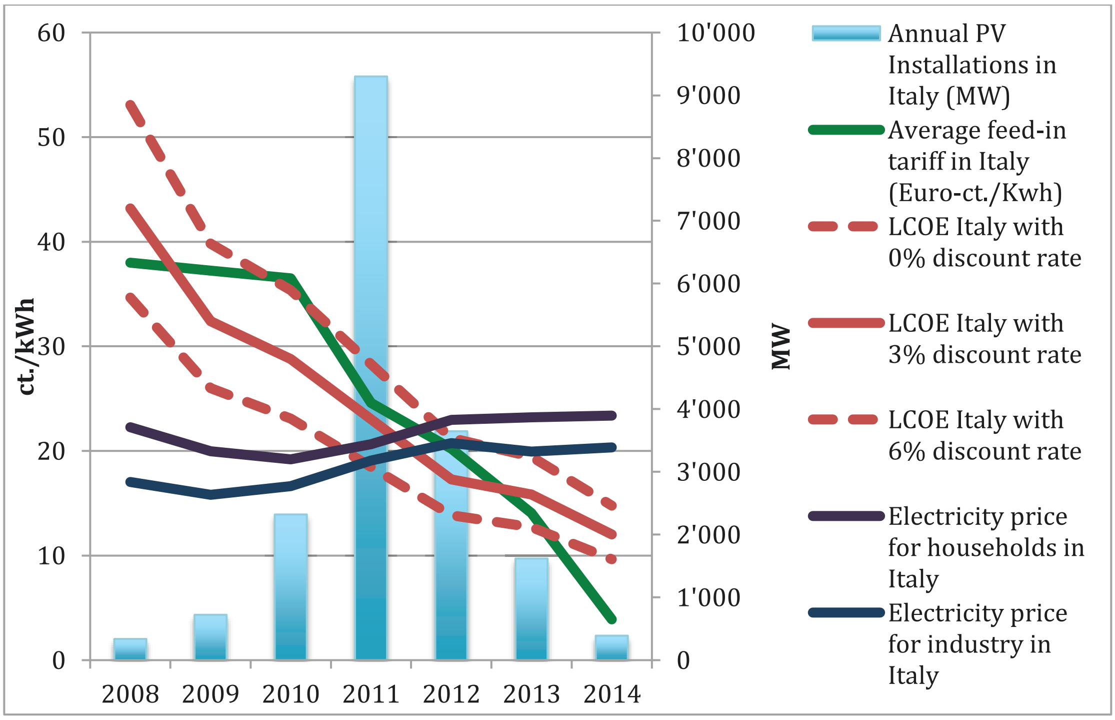

Figure II-6 New PV capacity, average FIT, PV LCOE and electricity prices in Italy by year

Policy and risk

Italy introduced PV feed-in premiums in 2005 with the programme 'Conto Energia'.

Although in the beginning no specific annual degression rate was applied, the tariffs were reduced and regulations changed every year and often several times in one year (GSE, 2015a; MiSE, 2012). Since changes occurred not in the same predictable manner as they did in Germany, the risk level for Italy in our estimation is 2 until 2012.

In 2011, 'Conto energia V' again introduced several regulatory changes. The new law replaced feed-in premiums with feed-in tariffs for PV, and introduced a degression schedule for regular tariff reductions. In 2012, the cap for overall spending on PV support was fixed at 6.7 billion euros. This cap was reached in June 2013.[10] Since July 2013, no new PV projects were eligible for feed-in tariffs and self-consumption premiums. Therefore, we raise the Italian risk ranking for 2013 in our assessment to 5.

Moreover, in July 2014 retrospective tariff cuts were applied to already installed systems above 200 kW (Pagni, 2014). Installations that were no longer eligible for feed-in tariffs became subject to revenue risk. Thereby, the combination of risk factors changed, since revenue risk replaced the risk associated with the cap on feed-in tariffs but the overall risk rating remained at the level 5.

Currently installations up to 200 kW can benefit from the net-metering scheme and tax deductions. Net-metering in Italy allows to use the electricity produced and fed into the grid as a payment for the electricity consumed over a year. The European Photovoltaic Industry Association estimates that about 40% of PV electricity generation benefited from this scheme in 2014 (Rekinger et al., 2015). However, only 16% of the produced electricity was actually self-consumed on a real-time basis (GSE, 2015a).

Plants of up to 1 MW can benefit from "simplified purchase and resale arrangements with small producers", a new scheme allowing to sell electricity to the GSE instead of selling it on the wholesale market. However, the price offered for solar PV electricity is lower than the average electricity price on the market. Therefore, we estimate that more than 50% of the investors are still subject to revenue risk, and give Italy an overall risk rating of 2 for the year of 2015. The decreasing risk rate reflects the certainty that feed-in tariffs are not available anymore.

The PV investor landscape and emerging post-grid parity business models

In the case of Italy, institutional investors represent a significant share of the market and typically own large ground-mounted installations. Similarly, utilities, which

[10] AEEGSI resolution 250/2013/R/efr, dated June, 6 2013.

used to have the largest share of electricity generation, own only a marginal segment of installed PV capacity.

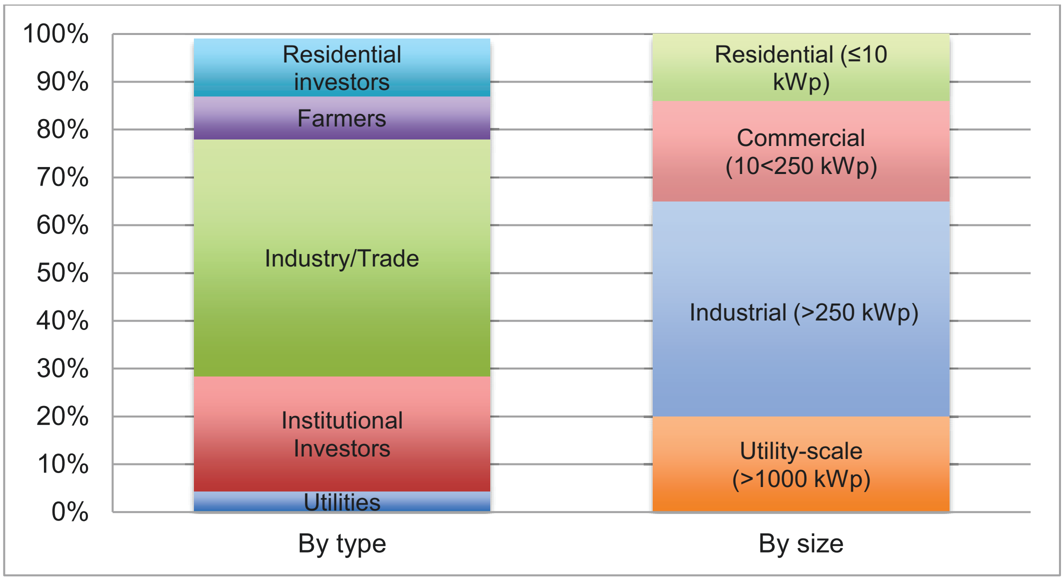

Figure II-7. Investor types and types of PV installations in Italy. Sources: GSE, 2015; AAEG, 2015; Solar Power Europe, 2015

Industry represents the largest segment of the investor landscape, which is similar to the German case (see Figure II-7).

Low cost of solar PV as well as an emerging trend to invest in solar PV without feed-in tariffs demonstrate the signs of an emerging post-grid parity world. Net-metering regulations mainly target savings-based business models. Minimum selling prices guarantees offered by *ritiro dedicato*, despite their low amounts, represent an attempt to hedge revenue risks for investors. However, the retroactive policy changes in Italy increase the perceived risk by investors and thereby discount the value of these price guarantees.

4.3 Switzerland

Market development: installed capacities and cost of PV

Compared to its neighboring countries Germany and Italy, PV diffusion in Switzerland is at an earlier stage. Feed-in tariffs on a national level came into effect in 2009, eighteen years after Germany. The electricity mix in Switzerland is dominated by hydropower (59%) and nuclear energy (37%). Concerns about security and external costs related to nuclear power, fueled by the Fukushima accident in 2011, have led the Federal government to propose a nuclear phase-out (SFOE, 2011). Even though parliamentary discussions over the past five years have watered down the Swiss energy strategy, there is widespread appreciation that renewable energy, and especially solar PV, will play an increasing role in maintaining a low-carbon Swiss electricity mix.

Due to the higher cost of labor in Switzerland and a less mature market, the levelised cost of solar PV is higher than in Italy and Germany. In combination with lower retail electricity prices, this creates a weaker case for retail grid-parity, although the trend of LCOE reduction is present. At the same time, feed-in tariffs in Switzerland are also still high compared to LCOE, offering positive returns. Annual installations grow, but starting from low levels in comparison to Germany and Italy. At the end of 2015, 433 MW of PV were supported by feed-in tariffs in Switzerland out of the overall 1'393 MW installed (IEA, 2015; Swissgrid, 2015) . This implies that about 70%[11] of the investors in Switzerland install PV applications without receiving feed-in tariffs, having to negotiate selling prices with their local utility.

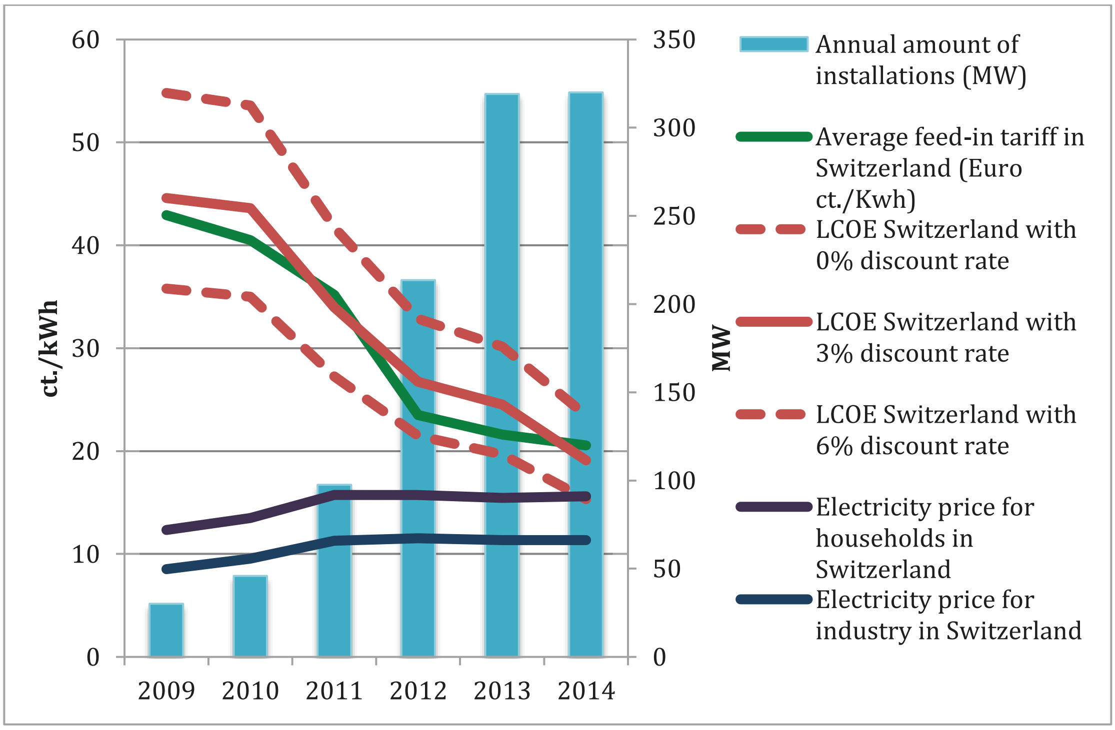

Figure II-8. New PV capacity, average FIT, PV LCOE and electricity prices in Switzerland by year

Policy and risk

Feed-in tariffs and waiting list

When the first legislation on feed-in tariffs was passed in 2008, Swiss incentives for solar PV were among the highest in Europe and guaranteed for 25 years, with a planned annual degression rate of 8% (Figure II-8). As in Germany and Italy, feed-in tariffs were refinanced from a mandatory surcharge on electricity bills (SFOE, 2014). As lawmakers were concerned about the impact on consumers, they put a

[11] Own calculation, based on Swissgrid's database of feed-in tariff applications.

tight cap on the level of the overall FIT surcharge, and an additional cap on specific technologies, with expenses for solar PV limited to only 5% of the overall funds. As a result, one day after Swissgrid started accepting registrations for feed-in tariffs on the 1st of May 2008, there were already more PV projects applying for support than funds available. This resulted in a quickly growing waiting list already before the actual start of the programme in 2009 (SFOE, 2008). Although the cap for solar PV was subsequently increased to 10%, a large amount of new applications led to a further build-up of the FIT waiting list and exposure of the large investor segment to volatile energy prices, while waiting to receive secure feed-in tariff, which is illustrated by our risk assessment.

The amount of support was also reduced at higher rates than 8% annually. Our calculations show that Swiss feed-in tariffs have been closely following the actual solar LCOE, unlike the cases of Germany and Italy, where feed-in tariffs have initially been more generous compared to LCOE. Relative to its neighbours, Switzerland has been more frugal.

Further initiatives in Switzerland aim to decrease the amount of installations on the waiting list, which in July 2016 consisted of about 35’900 PV projects with a combined capacity of over 2GW (Swissgrid, 2015)

Self-consumption support

Since 2015, installations under 10kW receive a one-off compensation covering 30% of the investment cost, installations between 10kW and 30kW can choose between this investment grant and feed-in tariffs, while for installations over 30kW the feed-in tariff remained in place. It is also worth mentioning that because of the federalist political system in Switzerland, many cantons and municipalities offer additional incentives for installing solar PV.

Rules for self-consumption were introduced in 2014. Residents are allowed to consume the produced electricity on site and feed the rest into the grid. For the share of electricity not self-consumed, PV producers get reimbursed either at feed-in tariff rates, or at the price negotiated with the local grid operator, or at market prices (SFOE, 2015).

The PV Investor landscape and emerging post-grid parity business models

The investor segmentation in Switzerland is similar to the one in Germany and Italy, with nearly half of the investments conducted by either private residents, or farmers, or small industry that can benefit not only and not always from feed-in tariff, but rather from self-consumption and energy savings. While there is no statistical data for Switzerland yet about how much of the produced electricity from solar PV was actually self-consumed, estimations suggest a number around 30% (Konersmann & Meier, 2015).

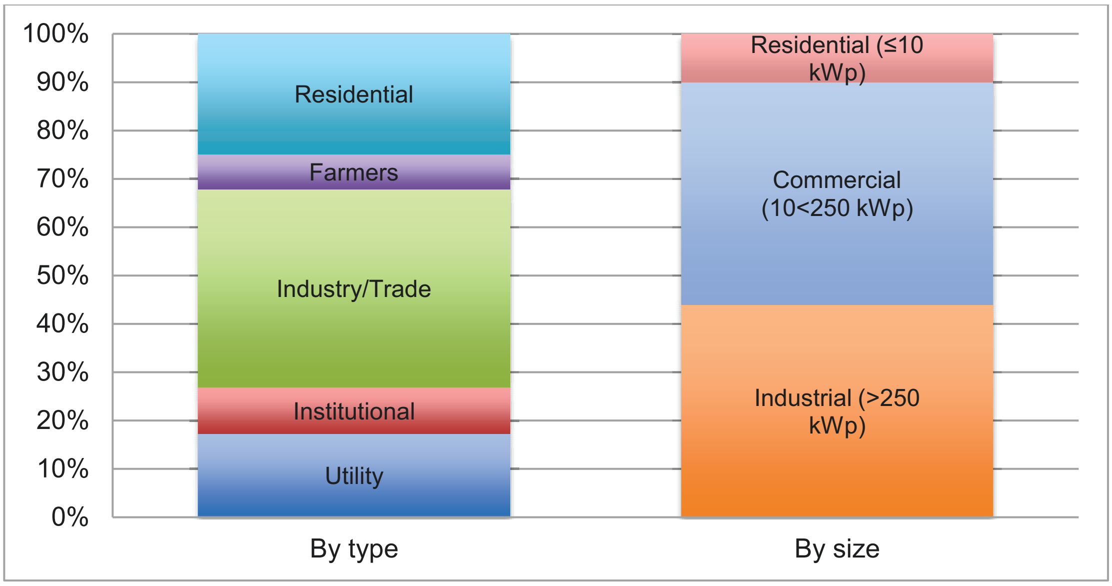

Figure II-9. Solar PV investors in Switzerland. Sources: KEV 2015, Solar Power Europe, 2015

5. Discussion: cross-case study analysis

5.1 The emergence of post-grid parity business models

The data on PV investor types in the three cases confirmed our expectations with regard to investor diversity. Residential investors and farmers, which are the investors who are most likely to be interested in savings-based business models, constitute between 20% and 50% of the overall investor pool in the three countries. These types of investors also typically have low cost of capital. Big utilities, on the contrary, constitute less than 5% of the overall investor pool in Germany and Italy. In Switzerland, the share reached 17%, which was to a large extent driven by smaller utilities, and is still not a large share considering the traditionally dominant role of utilities in electricity generation. Thus, the traditional pool of investors working with revenue-based business models and having high cost of capital is not very large.

Institutional investors, on the other hand, have lower cost of capital, which might be conducive for PV investments. According to recent research, this group of investors could contribute up to 50% of renewable energy investment (Nelson & Pierpont, 2013). However, considering the large investment potential represented by this group, there is still untapped potential for institutional investors in PV – their share currently varies from 10% to 24% in the three countries. Here, it is worth noting, that in the case of Switzerland and Italy, the current categorization of institutional investors includes not only financial players like pension funds or insurance companies, but also public institutions and service industry. Therefore, some of the investors belonging to this group might also be interested in savings-based business models. The same applies to the largest group in all three countries, industry, which includes companies ranging from PV project developers, who clearly implement a revenue-based business model, to small manufacturing firms who might be interested in savings-based business models. While calculating a precise share is difficult due to the lack of readily available data on specific consumption patterns for each category in the three countries, a plausible order of magnitude is indicated by the Italian case, where approximately 30% of industrial installations are suitable for self-consumption (GSE, 2015b).

Summing up the information above, we estimate that, depending on the country, from 30% to 60% of investors could be interested in savings-based business models. In the meantime, there is still a large share of investors in all three countries that invest under a traditional revenue-based business model, having different cost of capital depending on the company type.

As figure II-10 shows, the profitability of both business models show countervailing trends. We used the difference between average feed-in tariffs and LCOE as the proxy for the profitability of revenue-based business models and the difference between retail electricity prices and LCOE as the proxy for the profitability of savings-based business models. While revenue-based business models have lost their economic viability in Italy and are also at the verge of being unprofitable in Germany, the trend in Switzerland is less pronounced, with even a slight upward trend between 2013 and 2014. The profitability of savings-based business models, in contrast, shows the opposite trend in all three countries. While for Switzerland, relatively low retail electricity prices mean that savings-based business models are only marginally profitable, the higher prices in the two other countries make this business model increasingly attractive for investors in Germany and Italy.

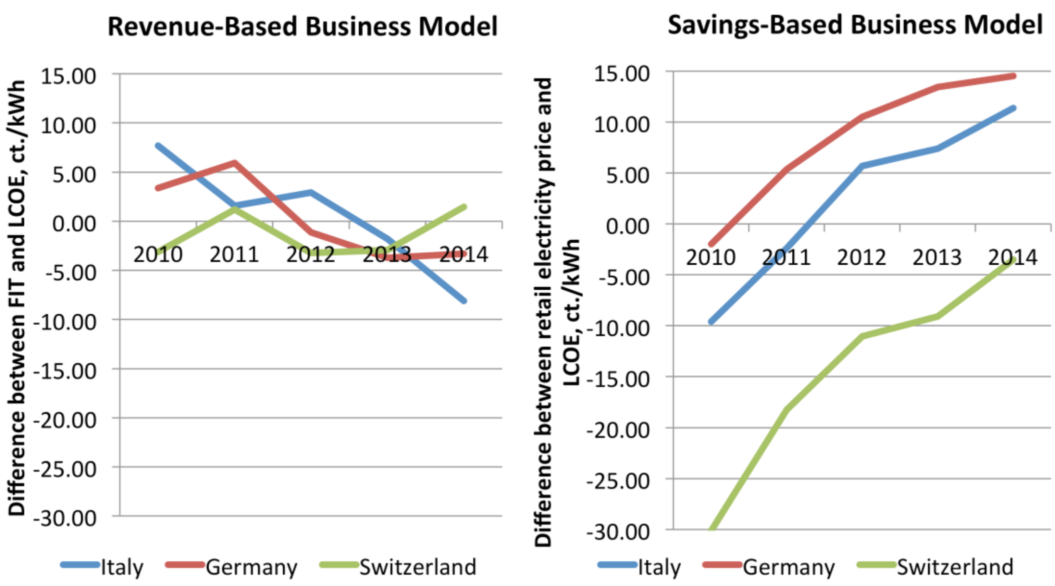

Figure II-10 Profitability proxies for revenue-based business models and for savings-based business models.

It is important to note that risk was not yet taken into account for this calculation. A specific limiting factor for savings-based business models is that not all investor types can consume their own electricity on site. As mentioned in the previous sections, Germany reached about 30% self-consumption, Italy 16%, while for Switzerland there is no reliable data available. The ideal case of 100% self-consumption can only be realized by massive changes in consumption habits or by making additional investment in battery storage, unless self-consumption is redefined by policy makers to relax the requirement of simultaneous supply and demand, as in the case of the Italian net-billing system that allows to deduct electricity fed into the grid from own consumption on an annual basis, regardless of timing. Thus, since very high shares of self-consumption are currently hard to reach, revenue-based business models and associated risks remain of relevance for the analysis of post-grid parity PV policies.

5.2 Risk as a moderating factor for PV grid parity

The deteriorating profitability of revenue-based business models in Italy and Germany presented in Figure II-10 shows a strong correlation with the decline in new capacity additions in those two countries in recent years, suggesting that the emergence of savings-based business models has not been sufficient to make up for the decreasing capital flows from investors in revenue-based business models. One of the remaining puzzles is why the relatively better profitability of those business models in Switzerland has not led to stronger growth in investments. We think the answer to this question becomes clear when considering the moderating role of risk. Figure II-11 combines our previous analysis with the risk rating for each country in each year (for details, see Figure II-3). When potential returns from feed-in tariffs are adjusted for levels of policy risk in the three countries, the risk-adjusted profitability looks rather sobering in recent years. The most striking case is Switzerland, where the situation around the feed-in tariff waiting list and more recently the decision to phase out feed-in tariffs completely around 2022 have made return prospects for the majority of investors highly uncertain. Those investors who realize revenue-based PV projects in the current Swiss context appear to either underestimate the level of policy risk or act based on idealistic motivations.

Our analysis of risk-adjusted profitability for revenue-based business models has an important policy implication. While feed-in tariffs have originally been designed to provide guaranteed returns, they are increasingly associated with risk. If returns from feed-in tariffs are adjusted for this increasing risk, then profitability of revenue-based business models turns negative in all three countries. As a consequence, taking the moderating role of risk into account is one of the key explanations for decreasing levels of PV investment in the advent of grid parity. If policymakers want to see continued flows of private capital to this sector, they have to either reduce policy risk, or provide sufficient returns including an adequate risk premium.

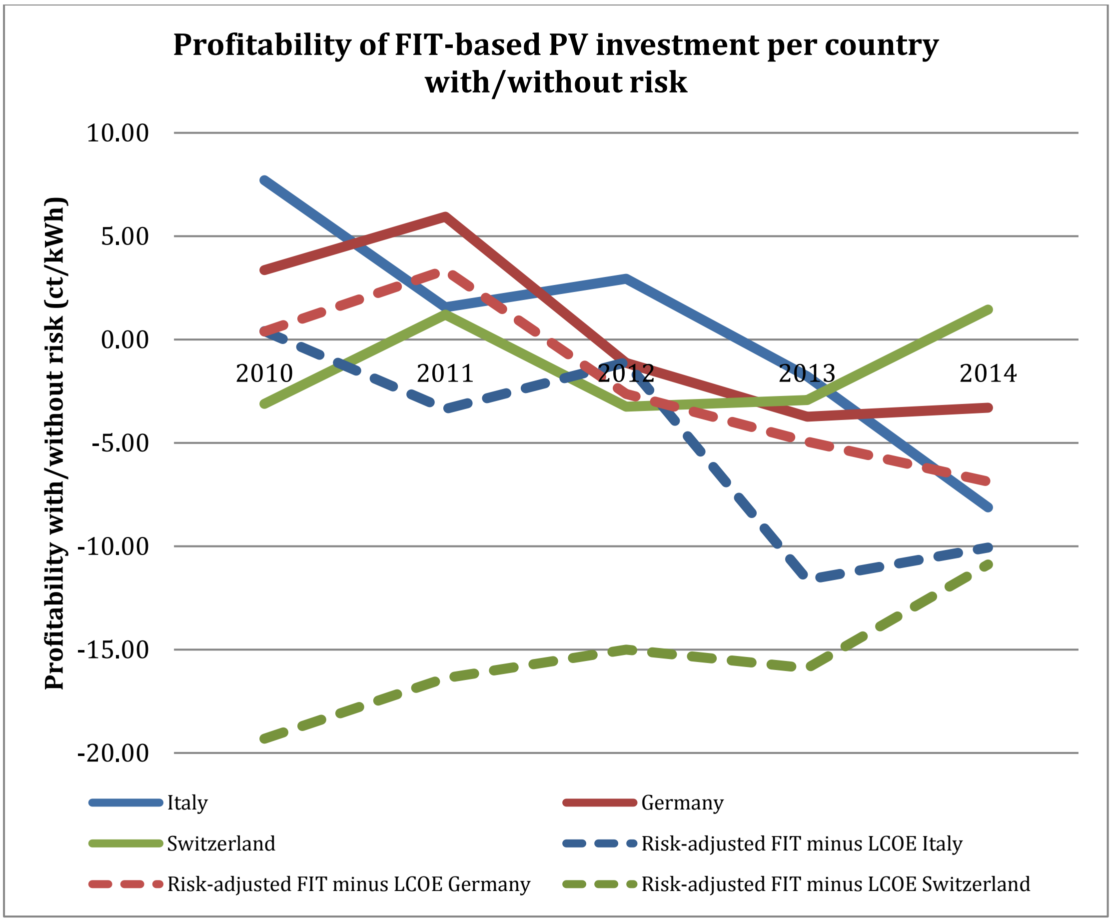

Figure II-11 Risk-adjusted profitability of revenue-based business models near grid parity

5.3 Surviving the policy valley of death: an advanced model for PV diffusion

Based on the empirical evidence in our case studies, it becomes clear that a model of PV diffusion, which envisions exponential diffusion occurring after grid parity is achieved, does not represent a realistic picture. Instead, we suggest an advanced model that more realistically describes the diffusion of PV (see figure II-12), and resembles the hype cycle of expectation dynamics known from other examples of early technology development (Fenn & Raskino, 2008).

In terms of explaining past investments, this model fits well with what happened on the Italian (green bars) and German (blue bars) market. After initially dynamic growth in the pre-grid parity stage, both countries reached a peak of policy-driven returns around 2011. Since then, increasing exposure of investors to policy and revenue risk has resulted in a slowdown of installation volumes in the near-grid parity stage. Right now, these countries find themselves in what we call the “Policy Valley of Death” – a situation where grid parity has been achieved but policymakers seem to have underestimated the moderating effect of increasing risk exposure on investor decisions.

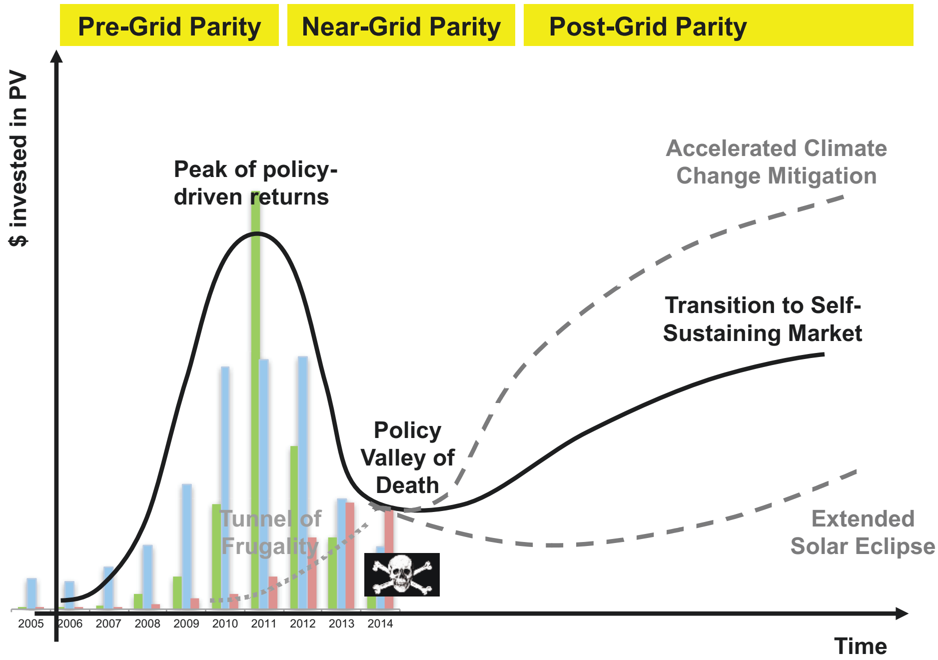

Figure II-12 Advanced model for solar PV diffusion

The emergence of savings-based business models, which provide a partial hedge against policy and revenue risk, can only compensate for this decline to a small extent so far. The Swiss case is somewhat different. While it can be argued that the Swiss PV market is also currently facing a policy valley of death, the country got there through what we call a “Tunnel of Frugality” – a policy regime with a tight cap on feed-in tariffs and high levels of policy risk which has led to comparatively low levels of PV investment.

What can be predicted from this model for the transition from the near- to the post-grid parity stage of PV market development? We suggest that there are three possible scenarios. The base case is the scenario “Transition to Self-Sustaining Market”, which could be driven by increasing attractiveness of savings-based business models. Because only 30-60% of projects lend themselves to self-consumption, and because simultaneous self-consumption rates are only a fraction of those, this base case will likely lead to a relatively slow growth of PV investments compared to the policy-driven growth that occurred in the pre-grid parity stages in Italy and Germany. Availability of battery storage would enhance the speed of diffusion, but also implies additional investment.

In the light of many governments' commitments to climate change mitigation, the relatively slow growth of PV in the self-sustaining market scenario may be unsatisfactory to policy makers. Therefore, we believe that some countries may choose to adopt a scenario of "Accelerated Climate Change Mitigation", which may lead them to revisit their feed-in tariff cuts – for example based on positive environmental externalities of solar photovoltaics – in order to allow for revenue-based business models to return to profitability. As a complementary measure, policy makers should be aware that apart from increasing returns, lowering risk for investors is an equally effective and sometimes cheaper way of improving profitability of PV investments.

In contrast to this positive scenario, there is also a third scenario, which we call "Extended Solar Eclipse". This can be driven by lack of understanding on behalf of policymakers, or by deliberate stakeholder action, for example aimed at negatively influencing the risk-return profile of savings-based business models. In countries where policymakers are unaware of the important roles of risk, investor diversity and business models for post-grid parity PV diffusion, this will result in suppressed levels of investment, basically extending the policy valley of death into the future. We hope that by writing this article, we have contributed to an enhanced understanding of these important moderating factors, and hence made a small contribution towards this scenario becoming less likely.

To summarize, we suggest that in the context of solar power, there is a case for an extended role of policy beyond the technology valley of death. Policy frameworks aimed at achieving climate change mitigation do not have to be very generous, as long as they maintain policy risk and revenue risk within limits that are acceptable for investors. Increasing the exposure to risk, in contrast, will result in a loss of some investor groups. If the ultimate goal is to attract enough private capital to the PV market, it may be wise to keep the current investor diversity and create a friendly investment climate for a variety of investor groups – those focused on revenue- as well as those focused on savings-based business models.

6. Conclusion and policy implications

With solar photovoltaics reaching grid parity, some policymakers now question the need for feed-in tariffs. By highlighting the moderating roles of risk, investor diversity and different business models on technology diffusion, our paper contributes to a more nuanced understanding of what determines investment in solar PV in the near- and post-grid parity stages of diffusion. We use a cross-case study analysis of three important European PV markets – Germany, Italy and Switzerland – to illustrate how increasing policy risk and exposure to revenue risk have impacted diffusion of PV. The empirical evidence presented in the three cases shows that there is a fine balance between phasing out feed-in tariffs and provoking a *Policy Valley of Death* that may occur when investors feel that they are no longer adequately compensated for remaining risks and market failures.

Our analysis suggests that the impact of feed-in tariff cuts depends on investor-specific cost of capital and the PV business model. All three PV markets investigated in this paper are characterized by a diversity of solar energy investors, including new players such as retail and institutional investors who are looking for a different risk-return profile than traditional energy investors. While low-cost-of-capital investors under the savings-based business model are relatively resilient to policy and revenue risk, high-cost-of-capital investors under the revenue-based business model are the first ones to get crowded out. If policymakers want to maintain levels of PV deployment that are in line with climate change mitigation targets, they should critically reflect upon the impact of policy changes on investor diversity.

As for the savings-based business model, we would caution that increasingly moving towards self-consumption is an attractive proposition from a system-wide risk allocation perspective, but it is not a panacea. In the absence of distributed storage, self-consumption in reality does not mean full autarky, therefore partial prosumers are still exposed to revenue risk for the share of electricity that they buy from and sell to the grid. Also, the political debate in different markets suggests that the savings-based business model is only a partial hedge to policy risk, as incumbent players are tempted to push for regulation that makes self-consumption relatively less attractive.

Overall, we conclude that in the next phase of solar market development, reducing policy risk and keeping at least a partial hedge against revenue risk are crucial ingredients of avoiding an “extended solar eclipse” scenario in which the flow of private capital to financing the energy transition dries up in the near-grid parity stage of PV diffusion. In the long run, moving towards a full-fledged post-grid parity world, the risk exposure can be gradually increased as long as a level playing field is warranted.

As the literature on post-grid parity solar policies is an emerging stream of research, our study is subject to some *limitations* that provide excellent opportunities for further research. First, while we analysed three key European markets at varying stages of PV diffusion, it would be interesting to extend this research to other countries. The UK may be a particular case in point, given the controversial debates about the future of solar feed-in tariffs that has created significant policy risk for investors.

Second, our exploration of the increasing role of savings-based business models is limited by a shortage of reliable and consistent data on self-consumption in the three markets. Further research may benefit from the increasing availability of such data beyond case studies of individual PV projects, and examine to which extent actual self-consumption models are an effective hedge against revenue and policy risk.

Third and finally, while we propose – based on an increasing consensus in the literature – that solar investors differ with regard to their risk-return preferences, there is still a shortage of rigorous empirical analysis on the cost of capital of different investor types. Such analysis is complicated by changes in preferences over time, for example reflecting the present attractiveness of other investment opportunities or the general interest rate environment. Further research could help policymakers get a deeper understanding of how the market will react to changes in feed-in tariffs, for example to what extent institutional investors will be crowded out if feed-in tariff cuts negatively affect the risk-adjusted returns of revenue-based business models, and how much of this gap can be realistically filled by other investors with lower return expectations or higher risk appetite.

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III. Paper 2. Implications of path dependence in investment decision-making: A cross-case study analysis of returns on gas and wind power projects

Yuliya Blondiau

Abstract

Renewable energy support policies in Europe have attracted new investors to the electricity market (e.g. farmers, communities, private households, institutional investors). However, while renewable energy investments were booming in Europe, many traditional utilities have refrained from making new investments or continued to invest in fossil-fuelled power projects instead. Can this be explained by the superior financial performance of these projects?

The objective of this paper is to evaluate the financial performance of realised wind and gas power plants by estimating their expected and realised returns. To fulfil the objective, a cross-case study analysis of 20 wind and gas power plants located in Germany, Switzerland and Italy was conducted. These plants represent typical project types implemented by Swiss investors during the 2004-2015 time period.

The results indicate lower realised rates of return on gas power projects, compared to returns on wind power projects. The reason for this is a lower than expected demand in the European electricity market. The paper concludes with the discussion of the role of policy for corporate decision-making in the energy field. Clear policy goals and climate targets can help companies make informed decisions and, when necessary, make timely adjustments to their investment strategies.

Keywords

Gas, Wind, Return on Investment, Path Dependence

1. Introduction

According to a recent study by the International Energy Agency and the International Renewable Energy Agency, to limit global warming to 2 degrees, renewable energy needs to grow from 15% of the global primary energy supply to at least 65% by 2040 (OECD/IEA & IRENA, 2017). Global investments in renewable energy are currently higher than investments in fossil fuels. However, nearly 150 billion USD continues to be spent annually on new coal and gas-fired power projects (REN21, 2017). In this regard, energy investors from Switzerland are no exception. Even though local regulation makes it very challenging to develop new fossil-fuel projects within the country, 30% of all energy projects financed by Swiss companies between 2004 and 2015 were fossil-fuel projects in foreign countries (BNEF, 2015).

Furthermore, global subsidies for fossil fuels are still more than double, compared to the funding for renewable energy support schemes (IEA, 2016). In Europe, for example, fossil-fuel subsidies exist in the form of capacity payments meant to support the electricity supply security (European_Commission, 2017). However, recent research illustrates that investments in gas-fired generation, which are often presented as temporary solutions providing flexibility for electricity systems, may lead to investment lock-in, due to high sunk costs. Thereby, this prevents the diffusion of other carbon-free technologies (Chignell & Gross, 2013).

The existence of multiple policy agendas supporting both renewable and non-renewable energy sources may increase uncertainty about the policy goals among energy investors. In the case of incumbent energy market players, which gained experience in dealing with large-scale fossil-fuel projects in the past, such uncertainty may contribute to preserving path dependence in their investment decision-making process (Wüstenhagen & Menichetti, 2012). The term 'path dependence' describes the situation in which choices made today are dependent on choices made in the past (Pierson, 2000).

Past dependence in decision-making by energy companies may manifest itself in a resistance to invest in new technologies, as well as a decision to invest in the fossil-fuel power generation familiar to these companies from their past experiences. Path dependence may also refer to the resistance of financial investors to include new types of projects in their investment portfolio (Bü er & Wüstenhagen, 2008). This paper focuses on choices between two types of energy projects: gas and wind power plants. Here, investments in gas-power plants implemented during the renewable energy diffusion in Europe are conceptualised as investments affected by path dependence.

This paper investigates the implications of path dependence in investment decision-making about new energy projects. It contributes to the energy policy literature by presenting the results of original empirical research on wind and gas power plant profitability under different support mechanisms. The role of energy policy in providing guidance for investment decision-makers in selecting energy generation projects and avoiding the negative implications of path dependence in their decision-making is also discussed.

The primary questions addressed in this investigation include:

- What were the expected returns for wind and gas projects and how did these expectations compare to the hurdle rate applied to these projects by the companies?
- What are the realised returns on these projects, considering their performance until 2015?
- If the actual returns do not match the expected outcomes, what are the reasons for this discrepancy?

Eighteen wind investment projects in Switzerland, Germany, and Italy, as well as two gas investment projects in Italy, implemented between 2006 and 2012 by Swiss investors, serve as case studies for the analysis. The gas projects were implemented by traditional utilities, while the wind projects were implemented by a variety of investors: a big utility, a project developer company owned by several small utilities, two independent project developers, and two project developers owned by local utilities and communities. To assure that the chosen projects are a representative sample of the wind and gas projects on the selected markets, the projects were chosen in such a way that their cost structure was within the range of the cost estimations for similar projects by such international organisations as the International Energy Agency and the International Renewable Energy Agency (IEA-WIND, 2013; IRENA, 2012).

The paper at hand is organised as follows. Firstly, a literature review provides the study background. Secondly, the method and data collection process is explained in detail. The results are then presented with reference to key variables that affected the performance of the power plants (i.e. demand, corresponding load hours, wholesale electricity prices, currency exchange rates, policy support schemes, uncertainties). Finally, the conclusions and policy implications of these results are discussed and recommendations for future research are made.

2. Literature review

Theoretical contributions about the corporate investment decision-making process suggest that decision-makers within organisations are not always acting in line with traditional rationality assumptions. Status quo bias is one example of how decision-makers may avoid implementing new strategies (Fernandez & Rodrik, 1991; Hambrick et al., 1993; Kahneman et al., 1991; Masatlioglu & Ok, 2005). According to Samuelson and Zeckhauser (1988), individuals typically stick to their routines when making decisions under uncertainty, which means either doing nothing or repeating previous decisions (Samuelson & Zeckhauser, 1988). In the context of utility companies experienced in investing and operating large-scale fossil-fuel power plants, this implies either not investing in anything or investing in a fossil-fuel project. Traditional utilities are reluctant to adopt new technology, due to its incompatibility with the firm's core competence or core capability in the conventional technology (Shah et al., 2013; Worch et al., 2013).

Another stream of the literature is focused on the organisational constraints in companies' decision-making. For organisations, the term "path dependence" is used more commonly to illustrate the lock-in effect of certain processes (Bebchuk & Roe, 1999; Sydow et al., 2009). Path dependence is characterizing the situation when technology prevails for historic reasons, rather than for its efficiency. The most famous examples are the QWERTY keyboard and the gauge of railway tracks (Puffert, 2002). Economists argue that path dependence contradicts the assumptions of the rational choice theory (Liebowitz & Margolis, 1995; Vergne & Durand, 2010).

Paul David, and later Douglas Puffert, discussed 3 reasons for path dependence (David, 1985; Puffert, 2002):

- Durability of capital equipment, which makes it 'cheaper' to use old and inefficient equipment, rather than buy new efficient equipment;
- Technical interrelatedness of the system components, making it easier to replace the parts of the system, rather than change the whole mechanism;
- Increasing returns, making market participants inclined to use an existing mechanism, rather than investing in the new one.

These points may explain the fact that incumbent utilities do not play a significant role in such renewable energy investments as wind or solar, compared to newly emerged investors such as households, farmers, financial investors (Bergek et al., 2013; Helms et al., 2015; Karneyeva & Wüstenhagen, 2017). If capital investment costs for the old energy infrastructure are already recovered and if operation costs are not higher than energy prices on the wholesale market, it might be easier to experience increasing returns by continuing to operate the existing power plants.

In the case of new investment decisions, the previous returns may play an indicative role in the choice of new investments. This role may be both implicit and explicit, as previous returns are often translated into shareholders' and creditors' expectations. Thereby, it may affect the weighted average cost of the capital of the company (Donovan & Corbishley, 2016; Helms et al., 2015). In the case of European utility companies, previous experience in dealing with high risk fossil-fuel projects, which used to provide high returns, led to the higher average cost of capital. Consequently, this also led to higher return expectations for new energy projects, compared to return expectations by other types of investors who did not have the same experience and often compare energy projects to projects outside the energy market (Helms et al., 2015).

However, path dependence does not represent a state of determinacy, but rather a process including the following three phases: preformation, formation and lock-in (Sydow et al., 2009). The preformation phase is characterized by the broad scope of action, which gets narrower in the formation phase, because of the organizational path and self-reinforcing processes originating from the choices made in the preformation stage. The final lock-in phase is characterized by its deterministic characteristic and the actions that are bound to a defined path (Sydow et al., 2009). In the context of energy research, the term carbon lock-in has received a lot of attention, since this concept describes the reinforcing nature of the institutional, technological and behavioural processes preventing the diffusion of new carbon-free technologies (Seto et al., 2016; Unruh, 2000, 2002).

This paper conceptualizes investments in combined cycle gas (CCGT) power plants as investments made in the second phase of path dependence. It is assumed that the companies making such investments already had positive experiences making investments in thermal power plants in the past. That being said, they are not bound to only this type of investment and can still choose a new type of investment (e.g. a wind project).

One of the assumptions of the literature discussing carbon lock-in is that low-carbon energy technology is less profitable for investors, compared to fossil-fuelled generation (Seto et al., 2016). However, from the perspective of investors, gas power projects may be considered a higher-risk investment option, because there is not only risk on the revenue side, but also on the cost side, namely the risk associated with uncertain gas and carbon prices (Helms et al., 2015; Vithayasrichareon et al., 2015). Renewable energy projects, on the other hand, due to their low operating costs, are only subject to risk on the revenue side associated with wholesale electricity prices or policy risk, in case the technology is supported by feed-in tariffs or green certificates (Ecofys, 2016; Lüthi & Wüstenhagen, 2012). In this context, it is interesting to determine whether higher returns compensate for the extra risks associated with operating costs in gas power plants and which type of investment (e.g. wind or gas power plant) is more attractive economically.

Therefore, in the paper at hand, the financial performance of wind and gas power plants is compared based on the collected empirical data on realised investment projects. The previous research has often focused on costs when evaluating the economic attractiveness of power generation projects, or calculated profits, as a difference between costs and revenues for a selected time period (Colpier & Cornland, 2002; Di Cosmo & Malaguzzi Valeri, 2014; Peña et al., 2014). However, since in practice investors use the internal rate of return (IRR) as a measurement of the value of the investment profitability, this measure is also applied in this work (Jagannathan et al., 2016).

3. Methods and data

To compare the expected and realised returns of gas and wind energy investments, this research employs a cross-case study analysis of 20 investment projects implemented by Swiss companies during the 2006-2012 time period. Projects include 2 gas power plants in Italy, 4 wind projects in Switzerland, 9 wind projects in Germany, and 5 wind projects in Italy. The choice to focus on the projects implemented by Swiss companies was motivated by two reasons: first, since Swiss companies are internationally active, this allows for the comparison across projects in several countries; and second, this allows the collection of additional data and a validation of the results in face-to-face interviews with company representatives.

Wind and gas projects in Germany, Italy, and Switzerland serve as case studies for the analysis, since these were identified in the preliminary analysis of the

Bloomberg New Energy Finance investment database as the main project types implemented by Swiss energy investors. Thirteen investment cases in gas and wind power plants were selected from companies' annual and media reports, based on the availability of the data on individual parameters to be used for estimations and calculations. The information about expected and realised returns on a further 7 investment cases in wind energy was obtained on a confidential basis from company representatives.

The discounted cash flow model was used to estimate the expected and realised returns on the projects. The IRR (internal rate of return) is the rate at which the NPV (net present value) equals zero (Equation 1).

Equation 1. IRR Formula

$$0 = \sum_{t=0}^{n} \frac{\mathrm{FCF}_t}{(1 + \mathrm{IRR})_t}$$

where:

n = lifetime. n is assumed to be 30 years for gas power plants and 20 years for wind power plants. Even though wind power plants may provide a return beyond the 20-year period, this is the period assumed by the various support mechanisms in Europe.

FCF = annual free cash flows. These are estimated as a difference between annual revenues and annual costs.

Annual revenue = Revenue from electricity sales or feed-in tariffs + revenue from green certificates (when applicable) + revenue from ancillary services (when applicable) + revenue from capacity payments (when applicable)

Annual costs = Fixed operation and management costs (O&M) + Variable costs (e.g. commodity price, CO_2).

In this study, the internal rate of return (IRR) is calculated under two main assumptions:

a) Expected IRR – a potential return on the project if the number of operating hours corresponded to the number declared in the first media communication about the project, and the electricity, fuel and CO_2 prices remained constant.

b) Realised IRR – a return calculated by accounting for the realised amount of load hours in the operating years and the realised prices of electricity, fuel and CO_2. For the upcoming operation years, a number of load hours per year equals the average from the realised years. The electricity, fuel and CO_2 prices are held constant from the year of 2015. In addition, a sensitivity test is conducted to test the impact of alternative assumptions about electricity, fuel and CO_2 prices.

The estimation of the project cash flows includes the estimation of investment costs and annual free cash flows. The data on investment costs was collected from companies' financial reports and media communications. The data for expected annual electricity production is taken from the first media communication about the project. The data for realised annual electricity production was taken from the annual reports of the companies operating the projects.

To calculate the expected IRR, the electricity, commodity and CO2 prices are assumed to stay constant from the year that the investment decision is made. The existing data on electricity price predictions from 2006 are not used in this paper for two reasons: a) these data represent expectations for Switzerland, France, Germany, Luxembourg, Netherlands, Austria, and Liechtenstein, but not Italy, where the gas projects under investigation are located; and b) these data predict demand growth and electricity price increases since 2006, which would imply that using such data as a proxy would lead to higher expected rates of return than if the starting parameters were held constant (Peder & Christian, 2008). Therefore the assumptions for this analysis are kept conservative by using the electricity, gas and CO_2 price data of the investment decision year as proxies. The data for realised electricity, gas, and CO_2 prices were estimated based on the annual information from public sources for the realised years of operation. For the remaining operation years, electricity, gas and CO_2 prices were held constant from 2015. The proxy for future electricity production is the average production in the realised years until 2015.

Table 1 highlights the differences in annual free cash flow estimations used for the calculation of expected and realised IRR.

Table III-1. Differences in estimations used for the calculation of expected and realised internal rates of return.

Expected	Realised
Electricity price in the year that the investment decision is made (i.e. the year of the first media communication about the project)	Electricity price by year of operation. Projected for the next operation years equals 2015.
Expected electricity production amount, specified in the first media communication	Electricity production amounts by year of operation. Projected electricity production for subsequent years: average of current performance
CO_2 cost in the year that the investment decision is made	Average cost of the CO_2 by year of operation. Projected cost equals the cost in 2015.
Commodity price in the year that the investment decision is made	Commodity (gas) prices for the years of operation. Projected price equals the price from 2015.

Hurdle rates applied to the projects serve as benchmarks for comparing the expected and realised IRR. These rates help in understanding the performance implications of the chosen strategy. The information about hurdle rates was collected from the company documents; when company data was not available, the published market information on hurdle rates in a given location was applied (SFOE, 2016).

The final step of the analysis is the triangulation of the results through 5 interviews with company representatives. Interviews helped in gaining additional data and validating the assumptions, where applicable. More detail on cash flow estimations for combined cycle gas power plants and wind power plants follows.

3.1 Estimation of the costs and revenues for combined cycle gas power plants for the year 2015[12]

Costs

The costs related to electricity generation are composed of investment costs, as well as annual fixed and variable costs. According to investor media reports, the investment costs for case A, which was a 25% stake in an 800 MW base load power plant, constituted CHF 230 million. The investment costs for case B, which was an initial investment in a 48% share of a 104 MW peak load power plant that increased to a 62% share, amounted to CHF 50 million and CHF 9,2 million, respectively.

Fixed annual costs include operation and management costs (O&M), personnel, insurance, fixed gas transportation, and general and administrative expenses. These costs were estimated by an Italian energy consultancy Ref-e at €34,000 /MW installed (Canazza, 2015). Variable costs include commodity and CO_2 costs.

For commodity costs until 2011, this research employed the ITECccgt index, as a proxy. Until the gas market liberalisation in Italy, this index estimated the average cost of producing electricity using a CCGT plant in Italy.

From 2012, due to gas market liberalisation, the Italian gas balancing platform, PBGAS G+1, provides a publicly available source of information about gas prices. However, to calculate the final commodity cost, one needs to account for gas prices and the cost of transporting each MWh of gas to the turbine, as well as the

[12] As data sources differ, depending on the year of operation, more detail for each year of operation are available upon request.

efficiency of the power plant in question and thermal losses during the electricity production process. The ITECccgt index included all of these components. Since the year of 2012, commodity costs can be calculated using the following formula:

Equation 2. Commodity costs

$$\mathrm{Pc} = \frac{(\mathrm{G} + \mathrm{T})*1.1}{\mathrm{E}}$$

where:
Pc = total commodity costs in EUR/MWh
G = cost of gas in EUR/MWh
T = cost of transporting each MWh of gas to the turbine
E = efficiency rate of the power plant
Information about the efficiency rate of the power plant is taken from the company reports and media communications. While the average efficiency of a gas fired power plant in Italy is 50-53%, the gas power plants in this study have 57% efficiency.
The costs of transporting each MWh of gas to the turbine are variable logistic costs. They depend on the transport fees approved by the Italian Energy regulator and are applied to users that withdraw gas from the high-pressure grid. For calculation purposes, the average annual values of 0.6 EUR/MWh, published by the Italian Energy Regulator, were used (AEEGSI, 2015b). Since some gas gets lost in the generation process and the percentage of latent heat for natural gas is 10%, the formula also includes the multiplication of the commodity price by 1.1 to address this issue.
In 2015, the estimated price of gas was €16.44/MWh and the transportation cost was €0.6/MWh. This results in the following calculation: (16.44+0.6)*1.1/57%=€32.88/MWh. The CO_2 costs for the CCGT plants are relatively low, however, they still have to be taken into account. The selected power plant produces 0.388 tCO_2/ MWh, on average, according to the calculations based on the operator's emissions data. This matches the publicly available data for similar plants.
The information about the CO_2 price in 2015 is taken from EEX (EEX, 2016). The calculation of the CO_2 price results in the following: 7.2*0.388 = 2.8 EUR/MWh.
The summary of the gas, CO_2 and the total marginal operational costs is presented in the Table A.1 in the Appendix.

Table III-2 provides an example of the cost calculations for case A for the year 2015, summarising the data sources and calculations for fixed and operational costs.

Table III-2. Estimated costs for a gas power plant in Northern Italy in 2015

Costs	**Estimated value**	**Source**
KO&M - fixed annual costs	34000 Euro per installed MW (EUR/MWh)	Canazza, V. (2015). Non solo energia: il ruolo della capacità in un nuovo mode: REF-E [in Italian]
Gas price	16.4 EUR/MWh	Annual data for PBGAS G+1 from GME , Gestore dei Mercati Energetici [in Italian].
Transport costs for the transfer of the gas to the turbine	0.6 EUR/MWh	AEEGSI - Autorità per l'energia elettrica il gas ed il sistema idrico (2015). Componenti tariffarie addizionali alla tariffa di trasporto a copertura di oneri di carattere generale del sistema gas [in Italian].
Efficiency rate of the turbine & thermal losses	57% & 10%	Data from company website supported by data from Siemens
Total gas price	(16.4+0.6)*1.1/57%=32.9 EUR/MWh	
CO2 price	7.2 EUR/tCO2	European Energy Exchange (EEX, 2016)
tCO2/ MWh	0.388	Average from the annual data on the company website
CO2 price per MWh	7.2 EUR/tCO2 * 0.388 tCO2/ MWh = 2.8 EUR/MWh	
Variable operational costs	32.9 EUR/MWh + 2.8 EUR/MWh = 35.7 EUR/MWh	

Revenues

The main revenue streams for Italian gas fired plants include the sales of electricity on the wholesale market (MGP), provision of balancing/ancillary services to the grid operator (MSD), and a transitory capacity payment, introduced in 2004 to remunerate power plants, which support security of supply (Art. 5 of legislative decree 379/03). To qualify for a capacity payment, power plants should be eligible for providing ancillary services and delivering capacity during days of potential scarcity of generation capacity, defined in advance by the national TSO. Capacity payments are financed through the levy on the electricity bills paid by consumers (AEEGSI, 2015a).

To estimate the revenue from the electricity sales on the wholesale market, the production amounts provided in the companies' annual reports were multiplied by the average annual price in the respective bidding zone (overall, Italy has 10 bidding zones). This average price was only calculated for the hours where the electricity price was higher than the marginal production cost. For a gas power plant, which only sells electricity during peak hours between 08:00 and 20:00, the average prices for these hours were calculated, taking into account the hours where the electricity price was higher than the marginal production cost. The calculations of electricity prices were conducted using historical statistical excel spreadsheets provided by the electricity market operator, Gestore del Mercato Elettrico (GME, 2016). Sales on the forward market could not be estimated, due to incomplete data for the historical forward curves. Therefore, the assumed share of the turnover on the wholesale market was 100%. The values of the estimated wholesale prices are provided in Table A.2 in the Appendix.

The revenue estimation from the balancing and ancillary services, as well as the capacity payments, was determined using data from the report by the Italian Industry Association (Confindustria., 2015). According to this report, for an 800MW CCGT power plant, €15 million could be expected from providing balancing and ancillary services, while about €2 million would be received as a capacity payment.

Table III-3 provides an overview of the annual revenue estimations, based on the eample of case A in the year of 2015.

Table III-3. Estimated revenue for a gas power plant in Northern Italy in 2015

Type of revenue	Estimated value	Source
Electricity price on the wholesale market	54.15 EUR/MWh: the average wholesale price in the trading zone "NORD", based on the hours when this price is higher than the variable cost. For a peak power plant: data from the trading zone CSUD is used, and an additional limitation is applied. The analysis is only applied to the hours between 08:00 and 20:00.	Historical spreadsheets with hourly wholesale electricity prices in Italy by trading zones, published for the years of 2006-2015, by electricity market operator Gestore del Mercato Elettrico (GME, 2016)
Balancing and ancillary services	15,000,000 EUR for 800 MW or 3,750,000 EUR for 200 MW	Confindustria (2015). Proposte di riforma del mercato elettrico [in Italian].
Capacity payment	2,000,000 EUR for 800 MW or 500,000 EUR for 200 MW	

Since the projects were realised by Swiss companies in Italy, the monetary values of the annual costs and revenues were translated into Swiss francs using the historical exchange rate provided by oanda.com (Table A.4 in the Appendix for the exact values of the applied exchange rates).

3.2 Estimation of the costs and revenues for wind power plants in Italy, Germany and Switzerland

Costs

Compared to gas power plants, wind power plants do not use fuel and do not produce emissions during their operation. Therefore, they are only subject to capital investment costs and annual O&M. The data for investment costs were obtained from the financial and media reports of the respective companies. The data on the wind energy O&M costs in Italy and Germany were obtained from the IRENA report (IRENA, 2012). The data source for the O&M costs in Switzerland was the latest Swiss Federal Office of Energy report about renewable energy costs (SFOE, 2016). For one of the cases in Switzerland, the O&M data from the operator was available.

For the projects in Germany and Italy, the costs were converted to Swiss francs using the historical exchange rates published by oanda.com. The overview of the cost range for the analysed cases is provided in Table III-4.

Table III-4. Cost range for wind power plants in Italy, Germany and Switzerland

	Italy	Germany	Switzerland
Investment costs	Min: 1068 CHF/kW Max: 2678 CHF/kW	Min: 925 CHF/kW Max: 1826 CHF/kW	Min: 2300 CHF/kW Max: 2800 CHF/kW
Operation and management (O&M) costs	Min: 36 CHF/kW Max: 49 CHF/kW	Min: 54 CHF/kW Max: 62 CHF/kW	116 CHF/kW or 0.054 CHF/kWh

Revenues

All analysed power plants could benefit from renewable energy support schemes in their respective countries. In Germany and Switzerland, the operators of these power plants received feed-in tariffs. In both countries, a higher feed-in tariff was intended to cover the first 5 operating years and a lower feed-in tariff the next 15 operating years. However, in both Germany and Switzerland, the "Referenzertrag" tariff calculation model was in place, which is intended to support wind power development in different locations by allowing for the extension of the initial remuneration level, depending on the plant performance in the first 5 years (May, 2017; SFOE, 2010, 2014; WindGuard, 2014).

In the cases analysed in this paper, the production of electricity from the wind power plants was not high enough to result in a tariff reduction in Germany or Switzerland; in contrast, the high tariff was, in most cases, extended so that the overall support time reached 20 years.

In Italy, wind energy was supported through a RES quota obligation and tradable green certificates (TGCs) until 2012. At the end of 2012, this system was replaced with three incentive access mechanisms for wind power plants: direct access, access by registration, and access by auction, where registration and auction access are constrained by annual quotas (IEA-WIND, 2013).

Since the wind plants under evaluation were all installed by 2012, they can benefit from the old system and receive revenue from the sales of the electricity on the wholesale market, as well as revenue from the sales of the green certificates for 15 years. To account for the fact that wind power plant operators do not store energy and do not define the hours of the electricity sales, the average annual wholesale electricity price in Italy was assumed to be the selling price for wind power plants. This resulted in a lower price, as compared to the price assumed for gas power plants. The details of the electricity prices used for the analysis can be found in Table A.2 in the Appendix. The data on the green certificate prices in the operating years, as well as the projections of these prices for the remaining operation years, were taken from the study published by the Italian wind energy association (eLEMeNS, 2015).

4. Results

The results of the cross-case study analysis illustrate higher expected rates of return on gas projects (up to 35% for a plant intended for peak demand) and lower expected rates of return for wind energy projects (Figure III-1). However, the realised rates of return on gas projects were significantly lower than the return rates on wind projects. In addition, the rates of return were also lower than the hurdle rates applied for these projects.

The hurdle rates identified in the analysis vary across projects. These variations are due to different approaches defining these rates by the companies. More specifically, in some cases, the hurdle rates represent project-specific risk estimations, in others, the expectations were based on the company's weighted average cost of capital.

The hurdle rates for two gas projects and seven wind projects represent the weighted average cost of capital (WACC) of the utilities that invested in these projects. The hurdle rates for the remaining wind projects, which were implemented by other project developers, represent project-specific hurdle rates. Therefore, the hurdle rates may only be compared with the expected and realised returns on the respective projects; they cannot be interpreted as proxies for risk perception comparisons across the projects.

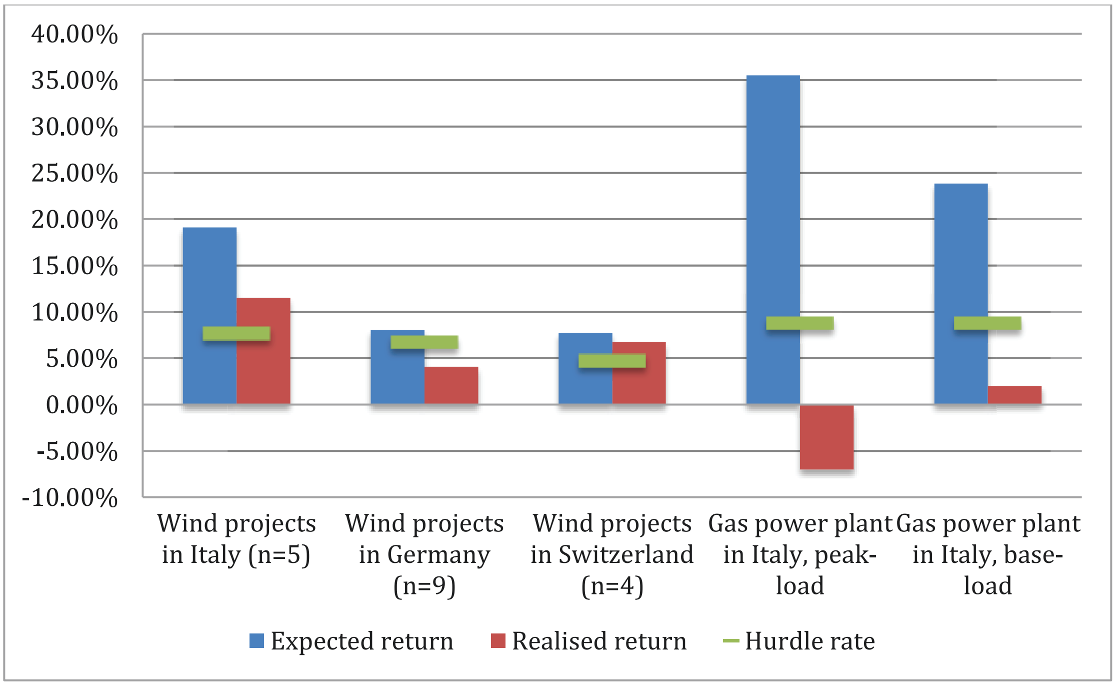

Figure III-1. Results of the cross-case analysis

The main reason for the discrepancy between realised returns on gas projects and expected returns, as well as hurdle rates, is the low electricity demand and the lower operating hours of the plants, than planned by investors. For instance, the base load power plant was expected to operate at a 57% load. However, it operated at only 35%, on average. The other plant was expected to operate at 54% during the peak hours, but only operated at 13%, on average (see Table A.3 in the Appendix for an overview of the annual load factors of the two gas power plants).

The difference between expected and realized returns is more pronounced in the case of the peak load power plant, since the difference between the peak and base load prices on the wholesale market declined over the last decade. Figure III-2 summarises the marginal production costs of the CCGT power plants, as well as the selling electricity prices for the peak and base load plants, estimated for the two analysed cases.

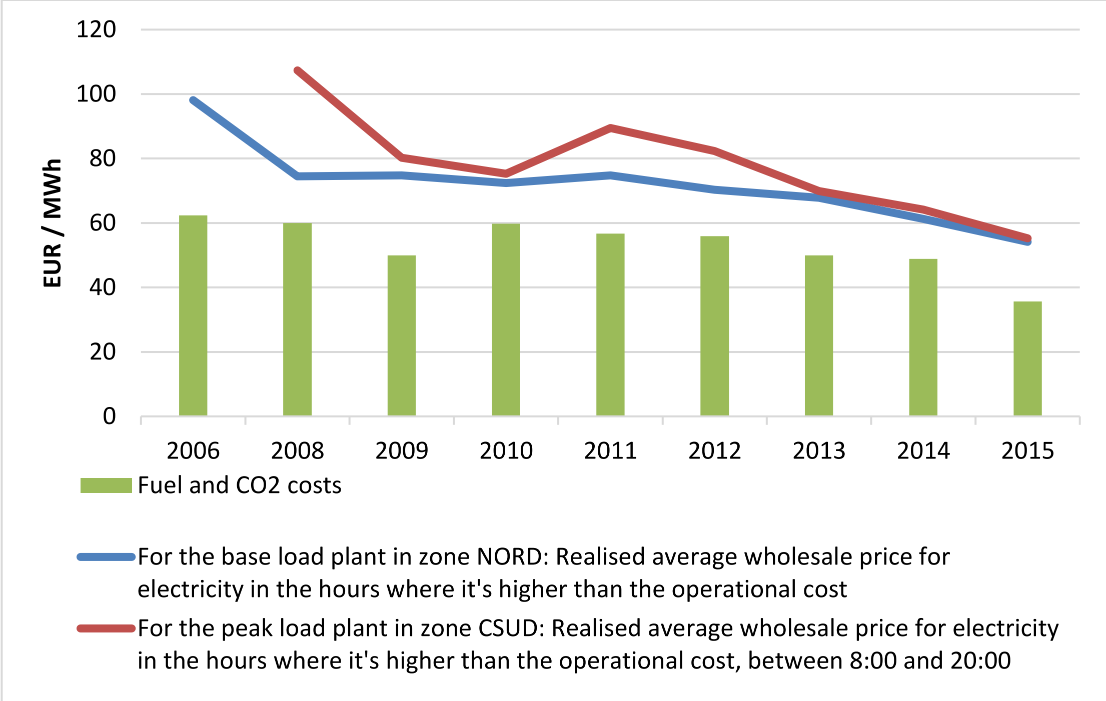

Figure III-2. Variable operational costs of CCGTs vs. wholesale electricity prices[13]

The sensitivity analysis for gas power plants illustrates that if we modify the assumptions and, for the remaining operation years by using averages from 2008-2015, rather than the latest data for electricity, gas and CO_2 prices as proxies, this results in the assumption of higher costs, but also higher wholesale electricity prices.

In recent years, the difference between peak and base load electricity prices was significantly reduced. Averaging the electricity prices from the years 2008-2015 increases this difference, and therefore, positively impacts the result for the peak power plant and negatively affects the result for the base load power plant. In the case of the peak load power plant, the higher selling price compensates for the higher commodity price. In the case of the base load power plant, the wholesale price is higher, too, but does not compensate for the higher commodity cost. Nevertheless, after the sensitivity test, the peak power plant renders a negative return and the base load power plant renders a low positive return, which is significantly lower than the hurdle rate of 8.8%.

[13] This study assumed that CCGT power plants are flexible (compared to coal power plants, for instance), and therefore, may choose to produce electricity only in the hours where the electricity price at least covers the variable operating costs, namely fuel and CO_2 costs. Since the two investigated plants are located in two different trading zones, the applicable electricity prices were calculated for each of these zones.

Table III-5. Results of the sensitivity test.

	Base case	Sensitivity test
	For the remaining operation years, the electricity, gas and CO_2 price equal the prices in 2015	For the remaining operation years, the electricity, gas and CO_2 costs equal the average from the years 2008-2015
IRR on base load gas power plant in Italy	2%	1%
IRR on peak load power plant in Italy	-7%	-4%

In the case of renewable energy projects, there is also a discrepancy between expectations and reality. However, the realised returns are still higher than the returns on gas power plants, and in most cases, are also higher than the applied hurdle rate. The discrepancy between expected and realised returns in the case of wind projects can be explained by the quality of wind forecasts. Apparently, wind forecasts for wind sites in Italy and Germany were higher than for locations in Switzerland. These forecasts were not always precise.

Currency risk affects the returns for Swiss investors. As a result of the annual cash flow conversion for the projects in Italy and Germany from Euros to Swiss Francs, the expected IRR tends to be higher than if it is calculated in Euros. However, the realised IRR is reduced by 1-3% for both wind and gas projects. This is due to the currency exchange rate variations between 2006 and 2015 (Table A.4 in the Appendix).

5. Discussion

The results illustrate that, despite the differences in estimations that may occur when different assumptions for electricity, gas and CO_2 prices are made, the returns on gas power plants are much lower than the expected returns and the applied hurdle rates. These results suggest that the traditional strategy of the energy companies, to invest in big fossil-fuel projects, assuming that the high risk will be compensated by high returns, may have negative financial implications.

Furthermore, the actual financial performance of the analysed gas power plants is significantly lower than the financial performance of the analysed wind power plants. This is the case, despite the fact that gas power plants were supported by capacity payments (ENEA, 2017). This suggests that, rather than improving the project profitability, the indicated capacity payments only sent a misleading message to investors, saying that the Italian energy market needs more gas power plants. Even though renewable energy support schemes were also in place at that point in time, several companies experienced in managing fossil-fuelled power generation seem to have chosen to pay attention to the investment options familiar to them. This has reinforced their organisational path dependence.

Recent policy developments, which include a reduction of support for renewable energies and discussions about new capacity mechanisms, continue to send such messages. For instance, in Italy, policy-makers consider paying up to €20,000/MW/year for the existing capacity and up to €75,000/MW/year for a new capacity. In the case of one 800 MW gas power plant, with a lifetime of 30 years, this can add up to 480 Million Euro subsidies, if it is already constructed, or 1.8 Billion Euro subsidies, if it is still planned (ICIS, 2017).

While investigating the exact amount and impact of the subsidies for fossil-fuelled generation in Europe is beyond the focus of this paper, the analysed cases of the gas power plants in Italy suggest that such subsidies may send a misleading message to the companies, which are already affected by path dependence in their decision-making process.

Furthermore, while in the recent literature, the reduction in wholesale electricity prices is often attributed to a diffusion of renewable energy, some studies from 2007 attributed the upcoming price reductions to increased investments in gas power generation (Clò et al., 2015; Fontini & Paloscia, 2007). If companies triggered by the subsidies make additional investments in fossil-fuelled power generation, this will lead to additional capacities on the market and lower electricity prices, causing even more need for policy intervention. This means that investors, in such a case, will continue to suffer from poor project profitability, while the government invests significant amounts of money in subsidizing these projects.

The trend of decreasing returns seems to not only affect the analysed gas power plants, but also other fossil power plants around Europe (Caldecott & McDaniels, 2014). In such a situation, it is up to the companies to choose their future path and up to the policy-makers to provide guidance for such choices.

6. Conclusions and policy implications

The analysis of the financial performance of gas and wind power plants illustrates that the path dependence in investment decision-making has led to negative financial implications for the companies that invested in gas power projects. The returns on gas power plants are significantly lower than expected, lower than the returns on wind power plants and lower than the minimum hurdle rates applied to these projects. The discrepancy is particularly high in the case of the analysed peak load gas power plant, since the peak load demand turned out to be much lower than estimated at the time of making the investment decision. Could this situation have been forecasted? Apparently, yes, since the investments were made at the time of the renewable energy boom in Europe. However, the utilities that made these investments seem to have had much higher return expectations on gas power projects, than on renewable energy projects.

These expectations might have been affected by the high estimations of electricity demand, which turned out to be much lower, in reality. While it is always challenging to make estimations of the future electricity demand, in the case of Italy, the estimations might have been distorted, due to the fact that policy-makers offered capacity payments for gas power plants, implying the need for these plants.

Unfortunately, policy agendas for renewable and non-renewable power generation often develop in parallel, which may result in a situation when feed-in tariffs and green certificates for renewable energy are introduced, while capacity payments for gas power plants exist at the same time, as was the case in Italy. This may lead to a situation where investors stick to their old investment strategies, assuming that the energy market needs new fossil-fuel capacities. However, in the context of increased investments in the market, no matter in which technology, there is a risk of overcapacities causing a decrease in demand and wholesale power prices.

This paper has important implications for energy policy research, as most energy economic models work either with technology cost estimations, or with future return projections, or with past return evaluations. Systematic comparisons between expected and realised returns yield important insights about possible biases in investor behaviour under conditions of policy uncertainty.

Both renewable and fossil fuel power projects are affected by a number of risks. While large fossil power plant projects suffer from a significant decrease in demand, renewable energy projects are subject to weather conditions and a number of risks related to policy changes. However, large fossil fuel plants also bear risks on the costs side, since the estimations for future commodity and CO_2 prices are unsure. On the contrary, renewable power plants do not bear these types of risks.

Hence, path dependence in investment decision-making in a form of sticking to old investment strategies may lead to increased risks and inferior financial performance. Is there something that policy-makers can do with the knowledge about path dependence in investment decision-making? Yes. Policy-makers may reduce uncertainty and provide guidance to investment decision-makers by introducing clear energy and climate targets and ensuring the reliability of policies to reach these targets.

7. Limitations and further research

This research on expected and realised risk-return profiles of power generation investments is subject to a number of limitations, which represent useful starting points for future research. First of all, data availability issues limited the scope of the cross-case study analysis to a relatively small number of wind and gas power projects. However, these projects represent typical project types implemented by Swiss investors over the last two decades and have the cost structure within the range of costs reported for such projects by the IEA and IRENA. Future research may benefit from access to data on a larger sample of such cases to gain more detailed insight for different project locations.

Second, due to data availability limitations, to calculate expected returns, the market conditions were assumed to stay constant since the investment year. Access to historical data about the predictions of electricity and fuel prices by country could allow future research to validate the results of this study and provide more detail about the factors affecting investment decisions.

Similarly, several cost and revenue parameters for the analysed projects were estimated using publicly available data. Future research could benefit from direct access to proprietary company data.

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Appendix: Input data for annual cash flow calculations

Table A.1. Variable costs estimations for CCGT power plants in Italy

	Gas price with efficiency of 57% (€/MWh)	CO_2 price (€/MWh)	Variable Costs (€/MWh)
2006 (investment decision for case A)	56.1	6.3	62.4
2008 (investment decision for case B)	55.0	5.0	60.0
2009 (first operation year for case A)	45.0	5.0	50.0
2010	55.0	4.8	59.8
2011	51.3	5.3	56.7
2012	53.3	2.6	55.9
2013 (first operation year for case B)	47.5	2.5	50.0
2014	47.0	1.9	48.9
2015	32.9	2.8	35.7
Assumption for the upcoming years	32.9	2.8	35.7
Alternative assumption for sensitivity test: average value in the operation years from 2008	48.37	3.75	52.12

Sources: GME, 2016, EEX, 2016.

For more details on calculations see Table III-2.

Table A.2. Wholesale prices, estimated for the calculations of project cash flows in Italy

	For base load plant in zone NORD: Realised average wholesale price for electricity in the hours where it's higher than the operational cost (€/MWh)	For peak load plant in zone CSUD: Realised average wholesale price for electricity in the hours where it's higher than the operational cost, between 8:00 and 20:00 (€/MWh)	For wind power plants in Italy - National Single Price PUN (€/MWh)
2006	98.119	Not applied in calculations since investment decision was made in 2008	Not applied in calculations, since power plants were bought between 2010-2012
2007	Not applied in calculations since operations started in 2009		
2008		107.35	
2009	74.8	Not applied in calculations since operations started in 2013	
2010	72.37		64.12
2011	74.76		72.23
2012	70.33		75.48
2013	67.87	69.92	62.99
2014	61.23	64.14	52.08
2015	54.15	55.25	52.31
Assumption for the upcoming years	54.15	55.25	52.31

Sourcs: GME, 2016.

For more details on calculations see Table III-2.

Table A.3. Annual load factors of CCGT power plants in Italy

	Peak load power plant	Base load power plant
Expected in 2006		57.08%
Expected in 2008	54.88%	
2009		37.00%
2010		39.98%
2011		40.13%
2012		26.01%
2013	9.99%	36.24%
2014	8.74%	24.00%
2015	20.73%	45.30%
Average load factor	13.15%	35.52%

Source: calculations based on annual reports of the operators

Table A.4. Exchange rate used for conversion of the annual cash flows

Exchange rate	(CHF/EUR)
2006	0.604
2008	0.60355
2009	0.67086
2010	0.67325
2011	0.80103
2012	0.82132
2013	0.8282
2014	0.81568
2015	0.83153
2016	0.92351

Source: oanda.com

IV. Paper 3. Why is the grass greener on the other side? Decision modes and location choice by wind energy investors

Yuliya Blondiau*, Emmanuelle Reuter*

Abstract

This study examines the role of decision modes, defined as the qualitatively different manners in which choices are made, in location choices, which are a type of investment decision. While prior research primarily emphasized critical antecedents of location choices, namely context-, task- or individual-level factors, this paper uncovers the critical role of the decision process, by investigating decision-making modes. Based on a verbal protocol study in a choice experiment of 12 location choices for wind energy projects, we uncover systematic differences in decision modes used and their interaction. We showcase that one particular type of decision mode, namely the recognition mode, leads to an asymmetric evaluation of the project location options and is triggered by institutionalized expectations and beliefs. With these findings, we contribute to the literatures, concerned with the psychology of location choices and investment decision-making, more generally.

Keywords: Investment Decisions, Decision Mode, Location Choice, Verbal Protocol Analysis, Asymmetric Evaluation

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1. Introduction

With increasing levels of globalization and cross-border investment opportunities, investors face important location choices. A question of central concern for investors is, in what geographical region to allocate their resources. In this article, we refer to *location choice*s as a type of investment decision, in which investors select whether to invest in opportunities in the home country or abroad.

Location choices have been a core research emphasis in prior international business/ strategic management, economics and in finance literatures (Alcácer, 2006; Berg, 2014; Chan et al., 2005; Cui & He, 2017; Dahl & Sorenson, 2012; Nachum et al., 2008; Rodgers et al., 2017). Taken together, prior research posited that higher levels of familiarity with the associated benefits of information, knowledge and access to social capital tend to trigger a *home country bias*, referred to as a disproportionately higher share of investments in the home country than in foreign countries (Ahearne et al., 2004; Huberman, 2001; Lewis, 1999; Portes et al., 2001; Tesar & Werner, 1995).

The focus of prior research on location choices has been on uncovering the effects of country-, institutional-, company- and project-level antecedents of location choices. This research has largely assumed calculative logic of investment decision-making and studied deviations from rational utility-maximization to explain investors' home country bias (Ahearne et al., 2004; Beugelsdijk & Frijns, 2010; Beugelsdijk et al., 2014; Coval & Moskowitz, 1999; Cui & He, 2017; Dahl & Sorenson, 2012; Huberman, 2001; Lewis, 1999; Tesar & Werner, 1995). Also, the more general psychology literature investigated into biases in investment decision-making, seeing these biases as "cognitive illusions"(Kahneman & Riepe, 1998), but still assuming that calculative logic should be dominating the decision process of decision-makers (Biais & Weber, 2009; Kahneman & Riepe, 1998; Olsen, 1997).

Yet, with this emphasis, much less research concentrated on the actual decision processes that investors use, and which play a critical role in explaining decision-making outcomes (Berg, 2014; Kahneman, 2011; Weber & Johnson, 2009; Weber & Lindemann, 2007). This may largely be due to the predominant use of variance-theoretical explanations and large-scale database research, at the expense of research designs that enable the study of the underlying behavioural processes and decision-making mechanisms to explain decision outcomes (see: Berg, 2014; Musteen, 2016).

In this article, we build on dual process theories of choice and decision-making in cognitive psychology (Kahneman, 2011; Weber & Johnson, 2009; Weber & Lindemann, 2007) and management research (Laureiro-Martinez, 2014; Louis & Sutton, 1991), which highlight that "how" decisions are taken may impact "what" kind of decisions are taken, to examine location choices. A core tenet is that people use different decision modes, which are defined as the qualitatively different manners, in which choices are made (Weber & Lindemann, 2007). In particular, Weber and Lindemann (2007) identify the calculation-, recognition- or affect-based modes in decision-making, which circumscribe the tendency that individuals make their choices rather analytically with reflection (calculation mode), automatically with association to the situation as one of a type, for which the decision maker knows the appropriate action (recognition mode) or based on emotions (affect mode). These decision modes, in turn, importantly shape decision-making outcomes. With the purpose to better understand the underlying decision modes in location choices, we address the following research question: What decision modes do investors use for location choices and how do these decision modes affect the location choice?

We opted for a natural decision-making approach (Klein, 2008) and purposefully selected location choices for wind energy projects as ideal research setting for addressing this research question (Wüstenhagen & Menichetti, 2012). A choice experiment, combined with think-aloud protocols (Ericsson, 2006; Isenberg, 1986; Mathias & Williams, 2017; Ryan et al., 2009; Schweiger, 1985), is conducted with 12 decision-makers representing institutional investors and investors from utility providers. The verbal protocol analysis, combined with an abductive theory-building approach (Bendassolli, 2013; Holmström et al., 2009), enables us to identify the decision modes that investors use, when they reason about location alternatives.

Our findings suggest systematic differences in the type of decision mode that is used by investors in their reasoning about home and foreign locations. We find that choices in general, and location choices in particular, are less determined by the distance-related factors (Beugelsdijk & Frijns, 2010; Kraus et al., 2015), the investor types, their backgrounds and experience (Mathias & Williams, 2017a), as perhaps assumed in prior research, but rather by the decision mode, with which they reason about choice alternatives. In particular, we argue that the recognition mode has the potential to lead to an *evaluation asymmetry*, referred to here as the failure to apply the same decision modes for evaluating choice alternatives. It is triggered by largely shared, institutionalized expectations and beliefs, and explains, why investors may deviate from the home country bias, and rather opt for the foreign country alternative.

This research makes a number of contributions to the existing literature. First, we contribute to international business, management, economics, and finance literatures, which studied behavioural aspects of investor decision-making and location choices and posited that higher levels of familiarity with the associated benefits of information, knowledge and access to social capital tend to trigger a "home country bias", when it comes to investment location choices. To the contrary, our findings suggest that, under some conditions, namely when investors have largely institutionalized beliefs relating to the constraints associated with the home country alternative, investors show a foreign country bias rather than a home country bias. By *institutionalized beliefs* about the constraints associated with investments in the home country, we particularly mean personal theories relating to the barriers to investment (e.g. complex permitting processes; high operational costs, worse wind conditions), rather than the advantages (e.g. financial benefits, social networks). Our results showcase that, because of such institutionalized beliefs about the constraints, investors may rather opt for foreign country opportunities than home country opportunities, despite similar financial returns of both alternatives.

Second, we are able to explain this finding by delving into the decision mode used. We find that investors' use of the recognition mode, triggered by largely shared, institutionalized expectations and beliefs, leads to an evaluation asymmetry among both choice alternatives. Investors tend to emphasize the constraints in the home market much more than the associated attractiveness. As such, investors tend to use the calculative mode much less than has been assumed in prior research. Thereby, we showcase that decision modes may cause factors that have been identified to be critical in prior literature (i.e. familiarity) to play out differently than argued in the previous research, i.e. lead to less investment rather than more.

At a more general level, we thus complement prior research, which primarily contributed variance-theoretical explanations by emphasizing critical antecedents (namely: country-, institutional-, company- and project-level factors) that determine "what" decisions are taken (Cui & He, 2017; Kraus et al., 2015; Musteen, 2016; Rodgers et al., 2017). By investigating "how" the decisions are taken, we contribute to a deeper understanding of the decision-making process or mechanism itself and the associated consequences. Specifically, the study advances a more nuanced explanation of the decision processes involved in investment decisions, their interactions and outcomes.

Finally, with our focus on location choices, we extend existing research on investment decision-making in energy markets (Chassot et al., 2015; Helms et al., 2015; Wüstenhagen & Menichetti, 2012) with another critical, yet under researched, type of investment decision.

2. Theoretical background

2.1 Location choice and home bias

Location choices have been of central concern in prior international business/ strategic management/ entrepreneurship and in finance/ economics literatures.

Previous international business and strategic management/ entrepreneurship research specifically investigated the international investments of different players, in particular of multinational enterprises, by looking, for instance, at research and development (R&D) investments or market entries (Alcacer & Chung, 2011; Basile et al., 2008; Nachum et al., 2008; Rodgers et al., 2017). A number of contributions also looked into the market entries of new entrants and of entrepreneurs (Cui & He, 2017; Dahl & Sorenson, 2012). This research uncovered the critical role of country- and institutional-level factors, such as regulatory and policy aspects (Bartik, 1988; Basile et al., 2008), state capabilities (Alcacer & Chung, 2007), state power (Cui & He, 2017) or the level of cultural distance compared to the home state (Beugelsdijk & Frijns, 2010) as determinants of location choices. Other contributions investigated company-level factors and its strategy (Chung & Alcacer, 2002) and, more recently, interactions between firm strategies and macro-economic conditions (Alcacer & Chung, 2014). At the project level, recent research investigated project type characteristics, such as, for instances, its speed, quality, interactivity, innovativeness, and routineness (Rodgers et al., 2017). Together, these researchers draw from comparative institutionalism and knowledge-based theories to explain the relationships between a range of country-, institutional-, company- and project-level determinants and location choices. Also finance and economics literatures dealt with location choices by looking into international financial streams and asset flows. They used, for instance, stock market investments (Chan et al., 2005) and international trade flows (Helpman et al., 2008), as indicators of location choices. A core emphasis in this research has been on the existence of a home country bias in location choices, for which scholars found systematic evidence (see Karolyi & Stulz, 2003; Lewis, 1999, for reviews in the international finance literature). The home country bias suggests that there is a general tendency to invest a disproportionately higher share of investments in the home country than in foreign countries. In other words, investors tend to prefer investing in the home country, compared to international alternative locations. To explain this observation, scholars found combined effects of barriers to international investments, on the one hand, and of the relative advantages of or preferences for investing in the home country (Chan et al., 2005), on the other hand. The latter authors find that the key barriers for international investments are the levels of development, of market capitalization and of transaction costs encountered in foreign markets. In terms of advantages for home country investments, previous research pointed to the critical role of economic and macro-economic factors, such as: investor protection, the level of economic development, capital control, and stock market development (see Chan et al., 2005, for an overview) for explaining home country bias. They further find the level of familiarity of the home country as key predictor. Familiarity is frequently operationalized as the level of similarity in cultural background (Grinblatt & Keloharju, 2001) and the geographic proximity (Sarkissian & Schill, 2004).

Also, international business and management research found evidence for a home bias of investors. The home bias is explained by investors' embeddedness in local networks and the availability of social capital (Dahl & Sorenson, 2012), as well as by distance-related perceptions of risk (Kraus et al., 2015). Yet, under some conditions, namely of high state power in the home country, investors may seek to escape the dependencies in the home country by investing abroad (Cui & He, 2017).

Together these prior bodies of literature tremendously advanced our knowledge of the determinants of location choices and of home country bias, in specific. Previous research largely inferred location choices from large-scale studies based on secondary data and largely drawing on economic theories. By doing so, they made a number of critical assumptions on the processes that underpin location choices and the hypothesized relationships. One key assumption has been that of utility-maximizing investors in the predominantly economic approaches to location choices (e.g. Alcacer & Chung, 2007; Bartik, 1985; Head et al., 1995; Nachum et al., 2008; Shaver & Flyer, 2000). However, by not looking at the actual decisions themselves and the underlying processes, prior research largely inferred that investors make their choices based on a calculative logic of the expected utilities of a location choice, namely by reducing risk and by maximizing benefits.

2.2 A behavioural perspective on decision-making and choice

Behavioural approaches to decision-making and choice point to actors' bounded rationality (Simon, 1955, 1997 [1947]), which imposes serious limits to the rational utility-maximizing logic of economic actors. Instead, behavioural perspectives suggest the existence of optimization failures and important biases, which predict deviations from the rational utility-maximizing logic of economic actors. In the context of investment decision-making previous research identified such biases as overconfidence, desirability, hindsight, and loss aversion (Biais & Weber, 2009; Kahneman & Riepe, 1998; Olsen, 1997). These biases are seen as "cognitive illusions", causing mistakes of judgment (Kahneman & Riepe, 1998). As a consequence, extensive research across different disciplines studied biases in investment decision-making.

In this respect, the literature on location choices, as outlined above, already points to the role of familiarity for explaining the occurrence of a home bias (Huberman, 2001). Rather than optimizing on economic outcomes, investors tend to satisfice, by opting for the best known or the most "familiar" alternative. By recognizing the existence of boundedly rational actors, much may thus be gained from a closer study of the actual decision mechanisms that underpin investment decisions.

In general, much less research addressed the cognitive processes involved in investment decisions, and even less so in the context of location choices. Instead, several contributions moved to studying individual-level factors, such as the impact of actors' roles and identities on their investment decisions (Fauchart & Gruber, 2011; Navis & Glynn, 2011). In this respect, Matthias and Williams (2017) empirically demonstrated how different roles assumed by entrepreneurs affected their investment decisions. These entrepreneurs were manipulated to take on different roles in an experimental setting while taking an investment decision. Others argued that the investor type and their prior experience with investments are crucial for understanding the strategic technology choices that they make (Wüstenhagen & Menichetti, 2012). Furthermore, scholars researched into the cognitive factors, 'a priori' beliefs and worldviews, in investment decisions (Chassot et al., 2014; Masini & Menichetti, 2012; Masini & Menichetti, 2013).

Despite a recently growing emphasis on individual-level and cognitive factors, this research either infers decision processes, with its emphasis on the impact of investor characteristics on decision outcomes, or investigates parts of the decision process, for instance, by looking at aspects of perception only. In turn, much less research looked into the actual decision mechanisms, whilst investors make decisions (Mathias & Williams, 2017). In this paper, we seek to address this shortcoming in previous research.

2.3 A dual process theory perspective on location choice

Dual process theories form an integral part of the behavioural approaches to decision-making and choice in cognitive psychology (Kahneman, 2011; Weber & Johnson, 2009; Weber & Lindemann, 2007) and in management research (Laureiro-Martinez, 2014; Louis & Sutton, 1991). Dual process theories suggest that people make decisions by using different decision modes. They point to the difference between actors' reasoning in an automatic mode, which involves little reflection, high reliance on the experiences made in the past, and reasoning in a calculative mode, which involves more deliberate thought, higher levels of reflection and greater distance from any type of assumption or experience made in the past. In particular, Weber and Lindemann (2007) advance that people use calculation-, recognition- or affect-based decision modes. Next, we describe the calculation and recognition modes in greater detail (see Table IV-1 for a detailed overview of the decision modes). We exclude the affect mode, as it is beyond the focus of the theorizing in this paper.

The calculation mode involves analytical thought. It includes calculation, in terms of traditional cost-benefit analyses or in terms of anticipated emotions. For the former, the motivational focus is oriented towards the maximization of material outcomes, and for the latter, towards the maximization of emotional outcomes. Cost-benefit analyses involve the evaluation of utilities, the evaluation and comparison of alternatives. These processes form an integral part of investors' daily job by analysing alternative investment options' risk and return profiles based on a range of financial parameters. A common method that is frequently used in this respect is the calculation of internal rates of return. After all, in for-profit organizations, the ultimate aim is the maximization of economic outcomes by making sound investments.

The recognition mode represents recognition of the situation as one of a type, for which the decision maker knows the appropriate action. The recognition mode involves the following subtypes: case-based, rule-based and role-based recognition. The motivational focus of the case-based recognition mode is geared towards efficiency and accuracy, of the rule-based recognition mode towards "doing the right thing", the justifiability of the choice, and of the role-based recognition mode towards connectedness, affiliation, and self-confidence. The case-based recognition involves cognitive processes with implicit categorization, whereas rule-based recognition involves cognitive processes with explicit categorization followed by if-then procedures. These processes are common for investors, who do not always calculate returns from scratch, but often make judgments about the project's risk-return profile based on if-then reasoning logics.

As reviewed before, the prior literature on location choices largely assumed that rational utility-maximizing investors engage in a calculative mode, when making investment decisions. In turn, much less research accounted for the possibility that investors engage in a different mode, when making investment decisions. Yet, given the insights on the critical role of different types of decision modes for decision-making outcomes, much may be gained, first, from an enhanced understanding of the type of decision mode that investors use when making location choices, and, second, of the conditions, under which they deviate from the calculative decision mode. We therefore seek to address the following research question: What decision modes do investors use in location choices? How do these modes affect investors' choices?

3. Method

3.1 Research setting

To address the above mentioned research question, we conducted a real-life choice experiment in a natural setting. In particular, we selected a location choice decision for wind energy projects as decision task. Location choices are common practice for professional investors in the energy industry (Lüthi & Wüstenhagen, 2012). By selecting a task that approximates participants' real-world decision-making, we sought to ensure the validity of the research design.

In the context of the energy transition from fossil fuels and nuclear energy to renewables, investors face critical strategic decisions about the location choice of their projects. In 2011, Swiss utility providers planned to invest 9.7 billion CHF in renewable energy until 2020, and two thirds of these investments were planned abroad (Windisch, 2011). Indeed, between 2004 and 2015, less than 30% of the new energy projects by Swiss investors were implemented locally, according to Bloomberg New Energy Finance (BNEF, 2015). Out of wind projects, only 8% were implemented locally, 42% in Germany and 12% in Italy. According to Windisch et al. (2011), companies located in Switzerland explained such a strong focus on foreign investments strategy at the time by limited wind and solar resources in Switzerland, a limited amount of locations appropriate for project development, more secure access to feed-in tariffs abroad, and simpler permitting procedures. In the meantime, energy investors from those countries that were potential foreign destinations for Swiss companies, pursued a similar strategy: German E.On, for instance, has 29% of its renewables' portfolio and only 12% of its wind portfolio in Germany (E.On, 2015). Italian Enel Green Power has 34% of its renewables' portfolio and only 8% of its wind portfolio in Italy (Enel, 2016). It follows from this data that there may be a tendency by energy investors to consider power generation projects at home as less attractive opportunities compared to power generation projects abroad.

Since the remuneration for wind energy projects in Switzerland has been higher than in neighbouring countries to compensate for supposedly higher costs, it is not obvious, whether wind projects abroad can be characterised by superior profitability compared to wind projects at home. Furthermore, both in Switzerland, where only 8% of investments were made by Swiss companies, and in Germany, where 42% of their investments were made, wind energy has been supported by feed-in tariffs. Additionally, the average reported capacity factor, characterising wind energy potential, has been the same in both countries between 2011-2015 (IEA_Wind). These empirical observations highlight that besides risk- and return-related factors there may be also cognitive factors that affect location choice decisions.

With our emphasis on a location choice task for wind energy projects as decision task, we purposefully selected a sample of 12 institutional investors and investors from utility providers from the Bloomberg New Energy Finance database's list of Swiss companies investing in energy projects (BNEF, 2015). Twelve respondents is an appropriate size and in line with previous verbal protocol studies that investigate decision processes (Isenberg, 1986; Mathias & Williams, 2017)

The final sample included seven investors from utility providers and five investors from institutional investment companies, who have comparable levels of experience in wind energy projects investments. In the utility provider sample, three international utility providers belong to the top five listed strategic investors in renewable energy from Switzerland; two international utilities belong to the top twenty strategic investors; two local utilities are shareholders of the specialised wind investment companies. International utility providers are highly positioned in the lists for asset finance and M&A as well. One of seven utility providers trades electricity on the wholesale markets only, and the remaining companies sell electricity to their local customers, since the electricity market in Switzerland is not fully liberalised.

The institutional investors sample includes the following companies: an investment fund of a Swiss bank, which was topping the list of the asset finance investors by BNEF at the end of 2015 and was the second on the list of the firms providing venture capital; a Swiss representation of the world's largest asset management firm; a Swiss fund specialised in renewable energy investments in Asia; a Swiss fund experienced in wind investments in Europe; and a Swiss insurance company with shares in the fund targeting renewable energy investments in Switzerland. Overall, 14 representatives of these 12 companies participated in the experiment. 11 had a Swiss nationality; further 3 had foreign nationalities (German, Greek and Italian) but resided permanently and worked in Switzerland. Therefore, we selected Switzerland as the home market alternative. Given that all participants were selected from Swiss-based companies, we could assume that they shared similar amount of knowledge about wind energy projects in the Swiss market. We selected Germany as the foreign market alternative, because, as specified before, Germany is the primary foreign market for investors in energy projects from Switzerland. To assure that the suggested wind energy projects in the experimental choice task are equally attractive for the companies, even with potentially differing levels of experience in international wind energy markets, we presented the projects as already constructed and ready to operate.

The overview of the respondents' sample, as well as the information about the interview dates is provided in Table IV-2. Next, we describe the methodology used in this paper, to address the research question elaborated above, in greater detail.

3.2 Methodology

In order to address our research question of *what decision modes investors use for making location choices and how these modes affect their choices* we conducted a choice experiment, combined with a verbal protocol study of participants' "think-aloud" protocols (Ericsson, 2006; Ericsson & Simon, 1980; Isenberg, 1986; Mathias & Williams, 2017). Choice experiments are frequently used in various disciplines to study the effects of selected independent variables on decision outcomes (Kraus et al., 2015; Lüthi & Wüstenhagen, 2012; Masini & Menichetti, 2012). A verbal protocol study, in turn, enables us to gather in-depth qualitative data on the decision-making process that is used for arriving at the decision outcome.

Participants in the choice experiment are asked to choose between the proposed choice alternatives, while "thinking aloud" or "speaking-out-loud" the reasons that govern their decision choice (Ericsson & Simon, 1980). These verbal protocols are then used to address the question of how decisions are made. A key advantage of the method over others is that it does not restrain the interview partners to conform to the researcher's expectations phrased as survey questions and, thereby, it is not likely to change the structure of the "germane" thought process (Ericsson, 2006). This method was used in management research (Chambers, 2014), consumer research (Bettman & Park, 1980), and at the intersection of consumer and management research (Schkade & Payne, 1994). Together, this research design allowed us to investigate both what and how the decisions are made.

3.3 Experimental design

In line with the assumption in prior literature of rational utility-maximizing actors' use of a calculative logic in location choices, we purposefully selected financial parameters that enable the calculation of the internal rate of return of different choice alternatives as decision input. The internal rate of return is a most commonly used measure of financial return by practitioners (Jagannathan et al., 2016). By doing so, we triggered participants' choice process with the calculation mode based on financial parameters.

To design the choice task and select decision parameters, we did two things. On the one hand, we selected variables, which were mentioned as the key variables affecting the investment decisions in the energy markets by prior research (Helms et al., 2015; Lüthi & Wüstenhagen, 2012; Salm, 2018). On the other hand, we empirically validated the decision parameters in a natural decision-making setting, by conducting focus group workshops with experts from the energy industry. 12 people formed the focus groups of 6 people each. All participants had considerable experience with energy markets in general and with Switzerland in particular. 10 of them were industry experts based in Switzerland, the remaining two were industry experts with good knowledge of the Swiss market, but located in another country. 4 participants were representing utility providers, 2 were project developers, 3 were institutional investors, and 3 were industry experts from academia. Together, there were 9 professional investors and 3 academic representatives. 10 participants were male and 2 female. The energy experts were asked to participate in a location choice scenario for a hypothetical wind park and to reveal what type of information they would need to be able to make the decision. Based on these inputs, we then expanded or deleted the initial decision parameters that we derived from the literature accordingly.

In line with the literature, experts highlighted that the following factors affect the rate of return of a wind project: the level of the feed-in tariff, overall project cost, project size and the annual electricity production potential, which is qualitatively referred to as good or bad wind conditions in a specified location. Furthermore, the focus group participants emphasized the role of the business model for their decision: A turnkey project ready to start operations was the preferred option, compared to a greenfield project, associated with permitting procedures.

Therefore, we focused on the following variables for experimental design: the level of the feed-in tariff, overall project cost, project size, the annual electricity production, and the business model.

To define the levels of the financial variables, we first collected empirical data about these variables on the selected markets (Table IV-3 in the Appendix).

Since there is a lot of variation in the cost estimations for wind power projects, we do not use the data from individual companies, but rely on the latest reports published by official state agencies or international organisations. Based on the collected information, we estimated the internal rate of return that could be expected on a wind project in the two locations. Assuming the project size of 6 MW and the project lifetime of 20 years, the calculation rended a 9% return for a Swiss project and a 0-3% return (depending on the level of operational costs assumed) for a German project. Such a difference can be explained by the higher remuneration in Switzerland, which is intended to compensate for the higher costs. The proportional difference in costs is, however, not as high as the difference in remuneration.

Thereby, we gained an overview of the variables affecting the financial returns on wind projects in Switzerland and in Germany and realised that, despite the larger share of Swiss wind investments being conducted in Germany, the average financial returns in this location may be less attractive than the average financial returns in the home country of investors. For the sake of offering equally attractive options in financial terms during the experiment, we modified the variables in a way that the calculation of annual project cash flows rends the same results for both locations. Specifically, we modified variables in a way, that the German project rends higher annual cash flows than the ones that can be calculated based on the reported empirical data: The two projects have the same investment cost, but the project in Germany is presented as the one of a bigger size than a Swiss one, and producing more electricity than reported on average (see Figure IV-1). The level of the feed-in tariff corresponds to the actual compensation level in the two countries in 2016, converted into Swiss francs for the German project (SFOE, 2014; SWE, 2017). Since empirical data suggests that annual operational costs for a bigger project in Germany would be higher than for a smaller project in Switzerland, which would again lead to a lower return despite the same annual cash flows, we leave the information about the annual operational costs out, to discover how/ whether investors evaluate them or ask for more information (IEA/OECD, 2015; SFOE, 2016; Vitina et al., 2015). Business model is the same for both cases, meaning investment in already developed and constructed wind onshore power plant. Revenues are generated from operating the plant and from receiving compensation through feed-in tariff.

By selecting the same decision parameters for both choice alternatives, and only modifying the value of some selected parameters, we seek to ensure that decision-makers are presented with two choice alternative that differ in terms of the selected parameters, yet, all else being equal. As such, if there were primacy, recency, or framing effects (Tversky & Kahneman, 1981) involved, they would be the same for both choice alternatives.The choice experiment question is as follows “Imagine you have to choose between two investment options. Which of the two projects would you choose?” (Figure IV-1). The data without pre-calculated cash flows is presented to the decision-makers, who, in turn, are encouraged to think aloud, while making their investment decision.

Imagine, you have to choose between two investment options. Which of the two projects would you choose?

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	Project A	Project B
Technology	Wind onshore	Wind onshore
Business model	Only operation, development and construction outsourced	Only operation, development and construction outsourced
Location	Germany	Switzerland
Feed-in tariff	CHF 90/MWh for 20 years	CHF 215/MWh for 20 years
Overall project cost	CHF 16.7 mln	CHF 16.7 mln
Project size	12 MW	6 MW
Annual Production	26,280 MWh	11,038 MWh

If you are not sure, please, explain what would you do to come to a decision, which additional information/equipment do you need.

Figure IV-1. Experimental task

3.4 Verbal protocol analysis

The verbal protocol analysis was designed, so as to collect rich data on investors' thinking process that underpinned the location choice. As investors were confronted with the two choice alternatives, they were invited to "think aloud" about the question which of the two projects they would choose and why. Their "thinking aloud" was recorded and transcribed verbatim. The interviews included questions besides the experimental task, which is the focus of this analysis. The reduction of the protocols was limited to singling out the interview parts concerned with the experiment. Participants were offered strict anonymity and confidentiality of their recorded statements, so as to motivate their honest reasoning accounts rather than official positions. Participants were senior executives of leading firms and possessed at least 5 years of experience in structuring investments in general (institutional investors) or energy investments in particular (utility providers). This way, we made sure that participants would be able to relate the experimental task to their daily business and understand the provided information. The participants agreed to spend working time on interviews and no reward was offered during the experiment. The major motivation for participation may have been interest in the study topic.

In terms of analysis, we used an abductive theory-building approach (Ketokivi & Mantere, 2010), continuously circulating between the data and existing theory on decision modes. Besides analysing *what* choice investors made, we, first, openly coded the interview protocols to identify first- and second-order themes that described *how* investors made their choice. Therefore, we used the Atlas.ti software. We soon realized that the taxonomy of the decision modes as proposed by Weber and Lindemann (2007) fitted what was going on in the data. We then decided to deductively code the entire protocols on the basis of the inputs suggested by Weber and Lindemann (Table IV-1) and organise those inputs using calculation and recognition decision modes as smart codes. We left out the affective mode, as it was less well represented in the data. This may be due to the nature of the decision task and the type of real-life professional setting, in which the experiment was conducted.

We used the “smart” codes feature in Atlas.ti for organising all the first-order codes into decision mode categories. The smart code feature in Atlas.ti means that the first-order codes, e.g. “evaluation of utility, importance of decision weights” and the respective underlying quotations, get assigned and counted towards the respective smart code “calculation mode” – the overarching category. Similarly, when investors made statements that we coded as “situational elements relevant to social role”, they were counted towards the “role-based recognition” sub-category of the recognition mode and ultimately towards the “recognition mode” category (Weber & Lindemann, 2007). In summary, this approach enabled us to uncover the reasoning process behind the location choices.

4. Results

In this section, we present the results of our analyses in the following two steps: 1. identification of decision modes, 2. relationship between decision mode and choice outcome.

4.1 Identification of decision modes

The decision modes identified in the analysis of the respondents’ reasoning about the location choice were: calculation and recognition modes.

As previously defined, the calculation mode category includes cost-benefit models, as well as anticipated emotions sub-categories, with the respective purpose of maximizing material and emotional outcomes (Weber & Lindemann, 2007). As for the cost-benefit sub-category of the calculation mode, we uncovered the following members: “Calculation/comparison of options”, “Attribute probabilities”, “Evaluation of utility, importance weights, decision weights”, “Maximisation of material outcomes". Our analyses did not reveal the anticipated emotions of the calculation mode, as proposed by the Weber and Lindemann taxonomy.

The following quotation by an institutional investor illustrates the code "Calculation/comparison of options": *"I just have to ... I can just get my calculator. That's too many millions for the moment. I'd like to have it in my head, but here I have to recalculate. 11038 it is - Yes, here I come to 2.3 million revenue. And here, I'm coming to the same thing here. What did I calculate there? Okay, I thought there might be more out here… Good to have a calculator with you. Good. Of course I have to – of course I have to think now".*

The recognition mode, in turn, is represented by the case-based recognition, rule-based recognition, and role-based recognition sub-categories (Weber & Lindemann, 2007). As for the case-based recognition, we uncovered the following members: "Implicit categorization/pattern matching", "Execution of if-then productions", and motivational focus on "efficiency accuracy". For rule-based recognition, we identified the following members: "salient situational elements", "explicit categorization", followed by "execution of if-then productions", and motivational focus on "Doing the right thing, justifiability-fairness/justice/self-control". Finally, the role-based recognition sub-category includes the following members: "situational elements relevant to social role", "recognition of role-related obligations and rights", and "execution of role-related obligations and rights".

The following quotation by a utility investor illustrates the "recognition of role-related obligations and rights" and the motivational focus on "doing the right thing": "*It depends on where I come from. Do I have too much money and want to just invest money? Or am I a responsible market player in Switzerland and I want to help realize the goals that we have set here? Then I would, then I would rather invest a Swiss domestic product, into a domestic product... If I want to fulfill my responsibility as a utility company in Switzerland and want to contribute to security of supply, I have to take the option in Switzerland, right?"*

In the meantime, looking at the motivational focus explicitly expressed by the respondents, we found that maximisation of material outcomes was the dominating motivational focus in the reasoning line of investors (see Figure IV-2). In 73% of the cases, investors expressed their motivation to maximise material outcomes. This means that often the inputs associated with role-based recognition, as well as occasionally – other recognition sub-types, occurred with the motivational focus applicable to the calculation mode. In the remaining cases, the motivational focus comprised "doing the right thing, justifiability, self-control" or "efficiency accuracy". "Doing the right thing" is associated with a rule-based justification of the location choice. "Efficiency accuracy" meant a motivation to perform a correct calculation of the choice alternative in question, self-corrections, emphasis on the long-term implication of the location choice and the issues associated with time length involved. Thus, the motivation of the most investors was the maximisation of material outcomes, but the reasoning was often done in recognition mode.

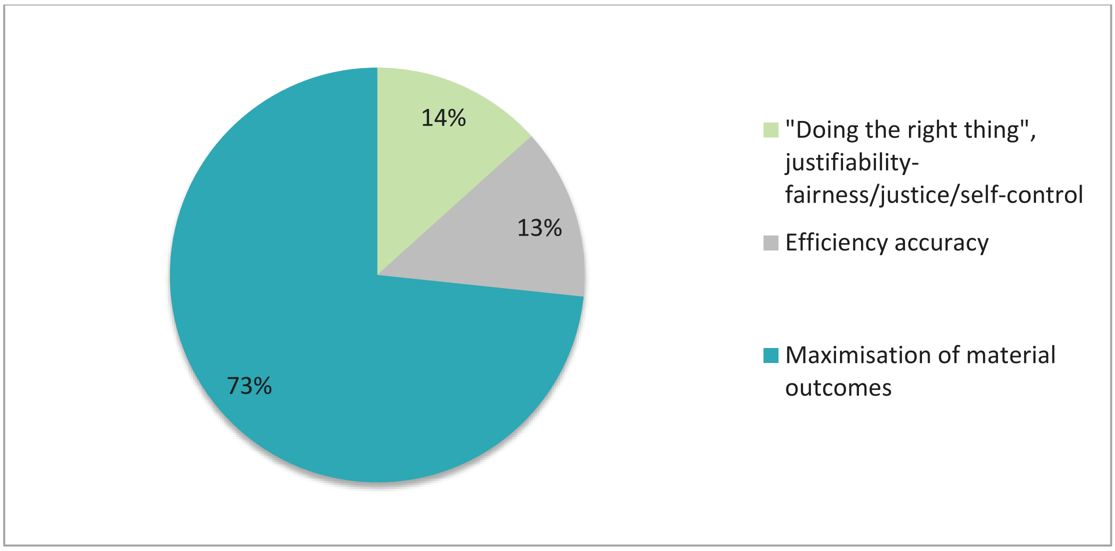

Figure IV-2. Motivational focus of investors

4.2 Triggers of recognition-based decision mode

Furthermore, we uncovered that the reasoning in a recognition mode was largely triggered by existing, institutionalised expectations and beliefs that were dominantly held by participants. Figure IV-3. illustrates the data tree for the coded institutionalized expectations and beliefs. Expectations were primarily geared towards perceived demands by political actors and by customers. Political demands were often associated with the perceived role-related obligations to contribute to the Swiss energy transition and having to invest locally for that purpose. The following participant statement illustrates such an expectation: "*And I believe that there is still a political component here in Switzerland. So if you could really buy a Swiss project that is similar in terms of return, I think, I'm sure it would not only be about good wind location. I am sure that political factors also play a role in these projects*". Customer-related demands included the assumed need to satisfy the local consumer with a local product, which should be more expensive, as the following statement by one of the participants illustrates: "*In the end it would always ultimately be about energy production for our customers. We would not invest just to make money*".

When reasoning in a recognition mode, investors further showcased the use of institutionalised beliefs, that is, largely taken-for-granted assumptions. They held strong beliefs about the profitability of wind energy projects and about the project implementation. To illustrate, they largely held the belief that the operational costs would be higher for the project in Switzerland or that the wind conditions are always better in Germany. Interestingly, these taken-for-granted assumptions do not match empirical industry data (see more quotations in Table IV-4). In terms of project implementation challenges, participants often disregarded the fact that the choice task included already constructed projects and expressed their concerns surrounding the permitting and construction risks associated with a choice alternative.

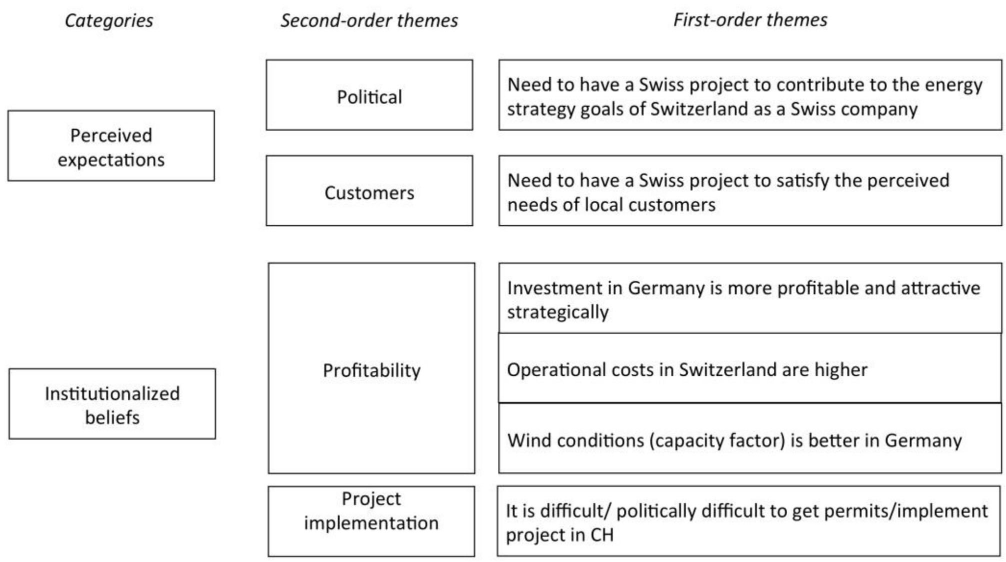

Figure IV-3. Data tree for institutionalized expectations and beliefs

4.3 Relationship between decision mode and choice outcome

Our results suggest important differences in the type of decision mode used and its relationship to the final location choice. This finding holds irrespectively of the investor type under consideration. The number of co-occurrences between the calculation decision mode and Germany as potential location choice was about 60%. In other words, when investors thought aloud about Germany as potential location choice, their reasoning was rather dominated by the calculation decision mode. In turn, the co-occurrences between the calculation decision mode and

Switzerland as potential location choice was only about 23%. That is, investors' reasoning about Switzerland as potential location choice was rather dominated by the recognition decision mode (see Figure IV-4).

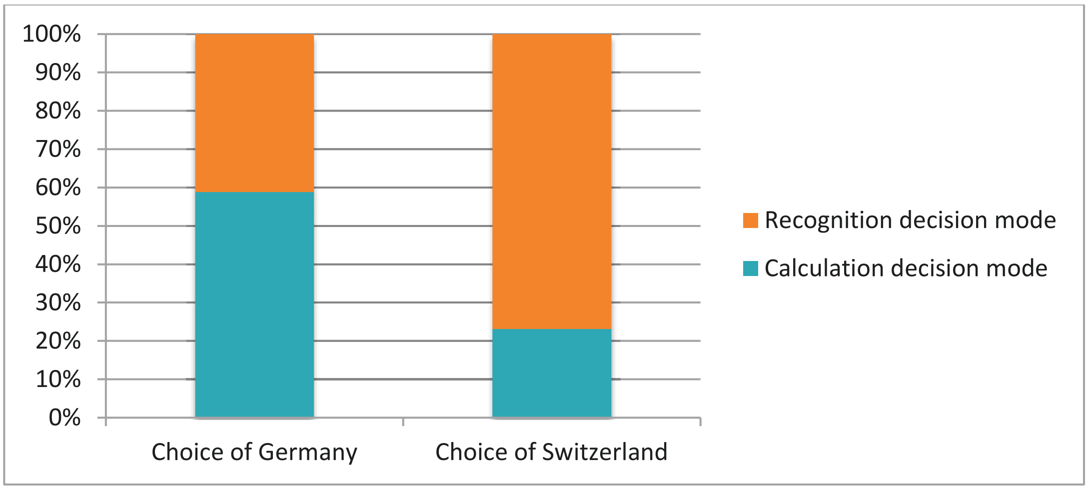

Figure IV-4. Co-occurrences between location choice alternatives and investors' decision modes

The following Figure IV-5 disentangles the relative occurrence of the decision mode subtype that are implicated in investors' location choice decisions.

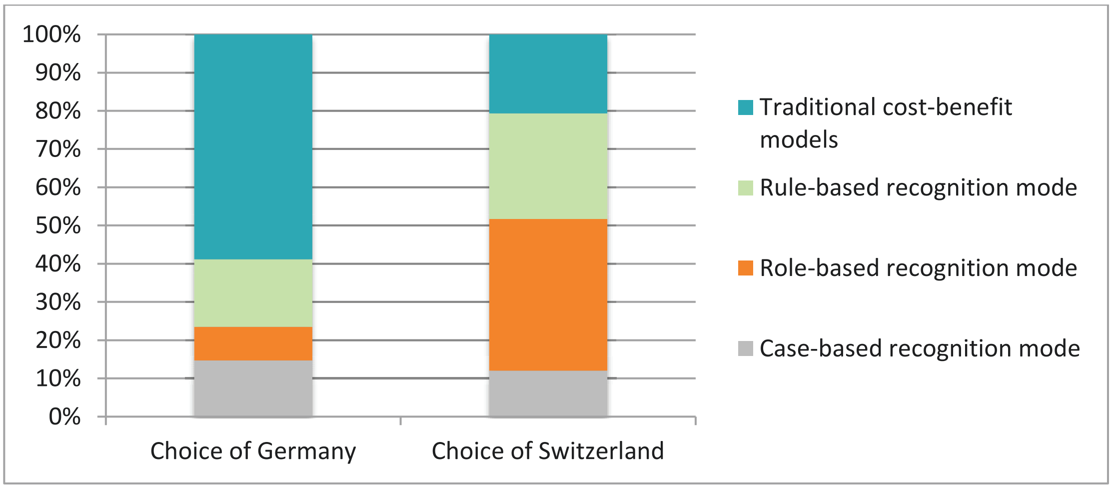

Figure IV-5. Co-occurrences between location choice alternatives and decision mode sub types

In summary, we found evidence for both the calculation and the recognition decision modes, as well as their respective sub-types: cost benefit modes, for calculation mode, and case-, rule- and role-based recognition for the recognition mode. We did not find the affection mode or "anticipated emotions" sub-type of the calculation mode. We also found that investors used the inputs and processes associated with the recognition mode via employing a number of institutionalised beliefs and perceived expectations, and having a motivational focus on maximisation of material outcomes.

4.4 Uncovering the role of asymmetric evaluation in location choices

Together, these results lead us to argue that, although investors seek to maximise profits as primary motivational focus, they tend to apply different decision modes in their reasoning about location choice alternatives, which largely depends on the location alternative under focus. In turn, the difference in decision mode used has critical implications for location choices, as it leads to an *asymmetric evaluation* of the choice alternatives. We introduce the notion of an asymmetric evaluation of the choice alternatives and define it, as the failure to apply the same decision modes for evaluating different choice alternatives.

We argue that the asymmetric evaluation of choice alternatives is largely due to investors' use of different decision modes and the factors that triggered the use of differing decision modes. In our case, investors used different modes, depending on the institutionalized beliefs and expectations associated with the location alternative under consideration.

In specific, investors' institutionalized beliefs about the constraints associated with investments in the home country, for instance beliefs relating to high complexity of the permitting processes, high operational costs, and worse wind conditions in Switzerland, compared to Germany, triggered the recognition mode for reasoning about the wind project alternative in Switzerland. Despite the choice task was designed, so as to trigger the calculation mode, with financial information as input, investors drew upon largely shared and taken-for-granted expectations and beliefs about the barriers and constraints of the Swiss option in a recognition mode. As such, the recognition mode overrode or prevented the calculation mode in investors' reasoning about location choice alternatives. This observation shows that the "familiarity" with the Swiss market prevented investors from applying the same reasoning and evaluation of the wind energy project in Switzerland, compared to the alternative in Germany.

Eventually, our results point out, that this asymmetric evaluation of the choice alternatives leads investors to discount a location choice alternative, which would bear similar financial returns, because of the institutionalized expectations and beliefs associated with the location alternative.

5. Discussion

The purpose of this paper has been to shed light onto the decision processes that investors use, when making location choices and to clarify their impact on the choices made. To do so, we built on recent dual process theories of choice and decision-making in psychology, which claim that decision modes play a critical role in explaining decision outcomes. By doing so, we make a number of critical contributions to the literature that looked into the psychology of investment decision-making and location choices.

First, our results add counterintuitive insights to the role of familiarity in location choices, as posited in prior international business, management, economics and finance literatures. A core argument of previous research on location choices is that “familiarity breeds investment and that investors have to cope with the risks associated with the lack of familiarity, in particular with the cultural, economic, institutional and political distance of foreign markets (Huberman, 2001; Kraus et al., 2015). Taken together, prior literature largely posits that lower levels of distance and higher levels of familiarity (with the associated benefits of information, knowledge and access to social capital) may thus have rather positive effects on location choices. To the contrary, our results suggest that familiarity may also have a negative impact on location choices. We found that investors may opt for the foreign rather than the home country alternative, namely under conditions of high institutionalized expectations and beliefs associated with the home country alternative. In particular, we uncovered that familiarity (institutionalized expectations and beliefs) may trigger a different reasoning mode, namely the recognition mode compared to the calculative mode, when investors make location choices. The recognition mode not only enables investors to seize the benefits, but also the barriers and constraints for investing in “familiar” markets. As such, our findings suggest the need for a more nuanced understanding of both the positive and negative sides of familiarity on location choices, depending on the type of positive or negative associations that investors make with a given location.

Second, by tapping into decision modes and their triggers, we complement prior research on the antecedents of location choices. We extend the focus of prior research on context-, task-, or individual-level factors that predict location choices, with an emphasis on the critical role of decision modes as mechanism and with the role of institutionalized beliefs and expectations as critical antecedent. Our findings suggest systematic differences in the decision mode used by investors across different location alternatives. In particular, investors tend to use a calculation-, or a recognition- based mode, when making location choices. Our results further suggest that decision modes may be less determined by the investor type – in our case: institutional investors or investors from utility providers – as proposed in prior research, than by the largely institutionalized expectations and beliefs that investors have developed with respect to one (in our case: the domestic) location alternative.

Moreover, and while we find, in line with the prior literature, that the motivational focus of investors is the maximisation of utility outcomes and, thereby, it should be aligned with the activation of the calculation decision mode. In contrast and counterintuitively, investors' reasoning is governed by the recognition mode. The recognition mode, in turn, leads to an *asymmetric evaluation* of choice alternatives, i.e. the failure to apply the same decision modes for evaluating different choice alternatives. In our case, an asymmetric evaluation was triggered by investors' institutionalized expectations and beliefs. Such beliefs and expectations are largely taken-for-granted by investors and drawn upon rather "automatically" in their reasoning (recognition mode) about choice alternatives. By automatically reasoning with expectations and beliefs with little calculation about the domestic choice alternative, the investors discounted the financial attractiveness of the domestic alternative.

The identified role of decision modes for location choices is consequential for several reasons. A key assumption of prior location choice research (which mainly drew upon variance-theoretical accounts) is that decision-makers follow a calculative logic. By disentangling both the motivational focus and the actual decision process, we showcase that despite the economic maximization is the major motivational focus, the actual decision processes, in which decision-makers engage, may under certain conditions (namely of institutionalized expectations and beliefs associated with one choice alternative) deviate from that motivation. As such, future research may be more careful in taking the assumption of the calculative logic for granted.

Moreover, and while we identified the critical role of institutionalized expectations and beliefs, it may not be the only antecedent to trigger the recognition mode. Future research may test for alternative antecedents that imply the recognition mode as underlying choice mechanism. For instance, future research may take into account the different types of experiences that investors previously had developed in a given market and how these experiences affect the location choice. In addition, much may be gained from further deepening our understanding of the possible and potentially complex interactions between the calculation and the recognition modes in future research. For example, future research may also investigate, whether and how the calculation mode overrides the recognition mode, as well as the conditions, under which this occurs.

Investigating into the actual decision mode, with which decisions are made, is critical. Because decision modes intervene as mechanisms between antecedents and outcomes, they may cause factors that have been identified to be critical in prior literature to play out differently, and thus explain as yet unexplained variation in outcomes. On a similar note, decision modes are critical, because they may trigger some decision-making biases or help overcome such biases. In this respect, our study importantly explains deviations from the home country bias. In a calculative logic, and under conditions of similar financial returns, the home country alternative would have been rational, given the superior “familiarity”, knowledge, resources and social capital associated with compared to the foreign country alternative. Yet, this study shows, that the recognition mode and triggered by the institutionalized beliefs about the constraints associated with the home location alternative, refrains investors to choose the home country alternative. As such, the decision mode used and its triggers has the potential to explain anomalies or variation in outcomes. Thus, by knowing which decision mode is at play, it helps shed light onto the underlying mechanisms that cause some antecedents to lead or not to lead to certain outcomes.

Our findings suggest that the recognition mode overrides the calculation mode in the reasoning about the home country alternative and that it is triggered by institutionalized expectations and beliefs. The recognition mode is a largely automatic reasoning mode, which may lead to highly biased results (Weber & Lindemann, 2007). As such, future research may further deepen our understanding of the critical role of decision-making biases that are associated with the recognition mode. For instance, it may test the impact and the reinforcing role of the anchoring effect on the activation and the overriding role of the recognition mode. In particular, some selected decision parameters (and the associated experience by decision-makers) may trigger the recognition mode by anchoring decision-makers’ reasoning on an investment, which they had been previously involved in.

Despite a number of key advantages of this study, it is subject to a number of limitations, which represent important avenues for further research. First, and in line with verbal protocol studies (Isenberg, 1986; Mathias & Williams, 2017) our analysis relies on a sample of 12 respondents. As professional investors, they represent a difficult-to-reach category of interview respondents. This sample size allowed us to gain critical insights into investors' reasoning in real-life choice decisions made by professionals. Moreover, by including professional investors, who differ in their experiences and institutional background, we sought to increase the generalizability of our findings beyond one particular category of investors. While our inductive study is exploratory in nature, future research may engage in large-sample studies with a larger number of professional investors, with the goal to further increase the generalizability of the findings, test the propositions made in this paper, and identify critical moderators and mediators that either enhance or weaken the impact of decision modes on location choices. Moreover, a large sample size may enable future research to control for potential confounding effects. To control for potential primacy, or recency effects, future research may randomize the presentation of decision parameters in the design of the choice task. Since the recognition mode is inherently subject to decision-making biases (Weber & Lindemann, 2007), such decision-making biases, like the anchoring effect, may play a critical role in triggering or in further enhancing the implication of the recognition mode. For instance, respondents with extensive related experience (e.g. having experienced a large number of complex permitting procedures in Switzerland) may be even more likely to anchor on institutionalized beliefs and expectations about a location alternative, and thus they may be even more likely to engage in the recognition mode.

In addition, future research may include a broader range of choice alternatives. We selected Switzerland and Germany as choice alternatives, because they represent the domestic and the foreign market that is most invested in. As such, we could ensure similar levels of knowledge of investors about both markets. However, the Swiss context of study has its peculiarities, since the local market of wind energy is not as liquid as the German market. On the one hand, this may have prevented respondents to apply a pure cost-benefit analysis in their evaluation of the suggested Swiss project. On the other hand, this peculiarity also supports our results, since the negative previous experience in selecting the domestic market as location for investment may be the reason for using the recognition mode for evaluating the alternative and for underestimating the potential gains from local investment. Future research may either manipulate choice alternatives in highly controlled experimental conditions, or extend the location choice alternatives, so as to be able to control for contextual effects.

Finally, future research may build on the insights gained in this paper to develop decision support systems, which help prevent evaluation asymmetries in decision-making practice. For instance, practices and tools that help raise awareness for shifts in decision-making modes may contribute to the alleviation of evaluation asymmetries and its negative consequences for "rational" decision-making.

A particular context, in which our findings may have important implications, is in policy communication. Our study reveals the distinctive effect of the recognition mode on decision outcomes. To illustrate, when double-checking the interview data, we found that in 7 of the 12 companies the interview respondents did not know about the benefits of feed-in tariffs in Switzerland. However, all of the respondents mentioned permitting complexity as a risk factor, even though the choice task explicitly excluded this risk factor. That is, when institutionalized beliefs and expectations are rather negative about a certain location choice, this may refrain investors from investing in that particular location and vice versa. Thus, to attract investments, policy communication may seek to shape positive connotations with institutionalized beliefs and expectations. In our case, this would mean focusing information campaigns on institutionalizing positive associations with the Swiss location (e.g. the benefits of feed-in tariffs rather than permitting complexity for wind energy projects in Switzerland). In this context, policy communication may also explicitly facilitate the use of calculation mode by, for instance, helping investors to predict financial risks and opportunities via providing specific online calculation tools.

6. Conclusion

Prior research, across different disciplines, uncovered a range of factors that predict location choices. A core tenet has been that the familiarity of the location facilitates investment and therefore investors tend to demonstrate home bias in their location choices. However, sometimes the grass may seem to be greener on the other side.

Our findings suggest that familiarity may also have a negative impact on location choices, because of the institutionalized expectations and beliefs that it may form. Investors, who access highly institutionalized expectations and beliefs, rather engage in a recognition than in a calculative mode to evaluate location choice alternatives. This, in turn, may imply an evaluation asymmetry, which we referred to as a failure to apply the same decision modes for evaluating different choice alternatives.

In summary, this paper uncovers the critical role of decision modes used in investment decisions and their impact on location choice outcomes. In particular, the paper uncovers the central role of the asymmetric evaluation of location alternatives, which is triggered by the institutionalized expectations and beliefs and the associated recognition mode, and has the potential to lead to a biased evaluation of alternatives.

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Appendix

Table IV-1. Taxonomy of decision modes. Source: Weber and Lindemann, 2007

Mode	Sub type	Inputs	Processes	Motivational Focus
Calculation	Traditional cost-benefit models (e.g., multi-attribute choice, risky decisions, etc.)	Attributes probabilities	Stage 1: Evaluation of utility, importance weights, decision weights	Maximization of material outcomes
			Stage 2: Calculation/comparison of options	
	Anticipated emotions	Anticipated emotions	Stage 1: Evaluation of anticipated emotions	Maximization of emotional outcomes
			Stage 2: Calculation/comparison of options	
Recognition	Case-based	Holistic situation	Stage 1: Implicit categorization/pattern matching	Efficiency accuracy (for experts)
			Stage 2: Execution of if-then productions	
	Rule-based	Salient situational elements	Stage 1: Explicit categorization	"Doing the right thing," justifiability-fairness/justice/self-control
			Stage 2: Execution of if-then productions	
	Role-based	Situational elements relevant to social role	Stage 1: Recognition of role-related obligations and rights	Connectedness, Affiliation/social identity, self-confidence/self-esteem
			Stage 2: Execution of role-related obligations and rights	
Affect	Needs (drives)	Presence of physiological need	Physiological response: instinctive and learned	Fulfillment of physiological needs
			Learned approach or avoidance response (operant conditioning)	
	Wants	Presence of want	Positive or negative associations (classical conditioning)	Fulfillment of wants autonomy, self-affirmation
			Learned approach or avoidance response (operant conditioning)	
	Immediate emotions (emotional) state	Aroused physiological (emotional) state	Aroused physiological (emotional) state, (operant conditioning)	Autonomy, self-affirmation

Source: Weber & Lindemann (2007)

Table IV-2. List of the investors

Company	Position	Interview date
A. International utility	Head of Generation Deputy CEO & Member of the executive board	02.03.2017
B. International utility	Senior Project Manager, Head of Acquisitions	20.03.2017
	Business Development Manager, Acquisitions, Power Generation	20.03.2017
C. Local utility	Head of Energy and Marketing, Member of Executive Board	23.03.2017
D. International utility	Head of New Energies Division, Member of Executive Board	30.03.2017
E. Institutional investor	CEO	03.04.2017
F. International utility	Head of Renewables and Efficiency, Member of Executive Board	04.04.2017
G. Institutional investor	CFO	06.04.2017
H. Local utility	CEO	07.04.2017
	Head Corporate Finance	07.04.2017
I. Institutional investor	Alternative Investments Associate	11.04.2017
J. International utility	Managing Director	12.04.2017
K. Institutional investor	Managing Partner	19.04.2017
L Institutional investor	Portfolio Manager Alternative Investments	09.05.2017

Table IV-3. Parameters affecting the project profitability in Germany and Switzerland in 2016

Parameters affecting the project profitability		**Germany**	**Switzerland**	**Sources**
Total project investment cost	In reported currency	1.246 mln €/MW	2.070 mln €/MW	IEA Wind, 2015
	In CHF	1.499 mln CHF/MW	2.489 mln CHF/MW	
Annual O&M costs	In reported currency	Min: 25 €/MWh; Max: 49 $/MWh	54 CHF/MWh	Vitina et. al, 2015; IEA/OECD, 2015; SFOE, 2016
	In CHF[14]	Min: 30 CHF/MWh; Max: 48.5 CHF/MWh	54 CHF/MWh	
Total level of remuneration in 2016	In reported currency	84 €/MWh	215 CHF/MWh	SFOE, 2014; SWE 2017
	In CHF	90 CHF/MWh	215 CHF/MWh	
Average reported capacity factor (on land), 2011-2015		19.7%	20%	IEA Wind, 2015
Pre-tax IRR on a 6 MW project that can be estimated using these parameters		0-3%	9%	Own calculation based on the annual free cash flows estimations using the parameters from this table

[14] The currency exchange rate is the rate published by oanda.com in the beginning of the year referenced in the data source. For example, if a report from 2015 refers to the data from 2012, the exchange rate for 01.01.2012 was used.

Table IV-4. Evidence for institutionalized expectations and beliefs

Category	Second-order theme	First-order theme	Quotations
Perceived expectations	Political	Need to have a Swiss project to contribute to the energy strategy goals of Switzerland as a Swiss company	Company A:"It depends on where I come from. Do I have too much money and want to just invest money? Or am I a responsible market player in Switzerland and I want to help realize the goals that we have set here? Then I would, then I would rather invest into a domestic product... If I want to fulfil my responsibility as a utility company in Switzerland and want to contribute to security of supply, I should take the option in Switzerland, right?" Company B: "And I believe that there is still a political component here in Switzerland. So if you could really buy a Swiss project that is similar in terms of return, I think, I'm sure it would not only be about good wind location. I am sure that political factors also play a role in these projects. "
	Customers	Need to have a Swiss project to satisfy the perceived needs of local customers	Company C: "It may be that for the Swiss customers a Swiss project, I mean wind energy from Switzerland, has a higher value. And if there is a readiness to pay more for Swiss electricity, then this qualitative element may speak in favour of the project B" Company H: "In the end it would always ultimately be about energy production for our customers. We would not invest just to make money".
Institutionalized beliefs	Profitability	Investment in Germany is more profitable and attractive strategically	Company F: "From the political point of view, as a Swiss utility, of course, if I have the opportunity to make the same return in Switzerland, then politically this looks nicer. From the entrepreneurial point of view, the other option looks better." Company A: "In the selection criteria, it certainly depends on what I am looking for. If I'm looking for a financial stake, I would choose Germany."
		Operational costs in Switzerland are higher	Company C: "Project in Germany would give me the cheaper procurement costs in the future. That would speak for the option A. " Company L: "Yes, you probably or even surely you have a bit higher operational costs in Switzerland."
		Wind conditions (capacity factor) is (always) better in Germany	Company B: "So for me, it's pretty clear how you would do that, we would do the German project, capacity factor is the best there and that means the economical attractiveness of the project" Company I: "I think in Switzerland there will not be very, much wind."
	Project implementation	It is difficult/ politically difficult to get permits/implement project in CH	Company I: "One should know, how long it takes from the start of the permitting process until the project is implemented. The barriers in Switzerland should be much, much smaller" Company B: "This process is much less standardized in Switzerland than in Germany, which is the opposite, it is the most developed market in Europe with clearer structures"

V. Overall conclusions

Investments in renewable energy play an important role in achieving global climate goals. However, uncertainties associated with these investments in Europe have not decreased in the last decade. The economics of renewable and non-renewable energy projects constantly change and the role of policy for renewable energy deployment is being redefined by both researchers and policy-makers. In this context, investor cognition, including risk perceptions and decision-making processes, still represents a field with a number of potential research questions.

The three papers of this dissertation contribute to the empirical and theoretical debate on the role of policy, project economics, and investor cognition for investments in renewable energy under uncertainty.

The first paper investigated the role of feed-in tariffs in a post grid-parity world, comparing the experiences from the solar PV markets in Germany, Italy and Switzerland. Theoretically, it made a contribution to the debate in innovation diffusion and transition literature about the role of deployment policies in late stages of technology diffusion. It also contributed to energy investment literature about the role of policy risk for investment decisions.

The findings of the paper demonstrated that the diffusion curve of renewable energy technology may be reminiscent of a hype cycle of investors' expectations rather than being an S-shaped diffusion curve. Furthermore, the findings of this paper suggest that, if investor diversity in renewable energy markets is to be preserved, then there is a role for deployment policies to play beyond their function of "buying down" the learning curve. Empirically, this argument is supported by the overview of the investor types in the Swiss, German and Italian energy markets, most of whom are new to the these markets and depend on secure returns. Another empirical contribution of this paper is the conceptualization and profitability analysis for the two major business models dominating solar photovoltaic investments: savings-based and revenue-based. The results suggest that only the investors focused on savings-based business models can truly enjoy the positive impacts of grid parity, and only if they manage to achieve a large share of consumption on the site. Thereby, the subsequent development of the diffusion curve of the solar photovoltaic technology largely depends on whether deployment policy will continue to exist and on the removal of existing or potential barriers to further development of self-consumption business models.

The second and the third paper took a Swiss perspective, aiming to address the empirical challenge associated with overinvestment abroad by Swiss investors, including investment in fossil-fuelled generation.

The second paper investigated implications of path dependence in investment decision-making by comparing the economics of the wind and gas projects implemented by Swiss companies in Germany, Italy and Switzerland. Theoretically, it contributed to discourse on path dependence by extending it from the discussion of path dependence antecedents to the discussion of the financial implications of path dependence. One of the theoretical arguments explaining path dependence is increasing returns. The paper shows that while increasing returns may form expectations with regard to investment projects, the reality may bring decreasing returns. Empirically, results illustrate higher returns on wind power projects compared to those on gas power projects.

The paper also discusses the role of policy for guiding investment decision-makers. Within the theoretical framework of Grubb (2004), the support policies for gas projects represent a barrier for renewable energy investment. If renewable energy diffusion is to move to a more advanced stage, it may be sensible to phase-out such policies. Empirical evidence showing low or negative returns on gas power projects, despite policy support, suggests that, from a financial perspective, it should make sense to avoid spending public resources on supporting fossil-fuelled projects, which will experience losses anyway.

The third paper shed light on how Swiss utilities and institutional investors decide on an investment location of a wind project based on the qualitative data on investors' reasoning while making an experimental choice between a project in Germany and a project in Switzerland. Theoretically, the paper demonstrated that decision modes play a role in choice of the geographical project location, which is at least as important as context-, task- or individual-level factors. In contrast to assumptions from the management and finance literature, familiarity of the local investment option is found not to create a home bias, but rather a set of institutionalized beliefs triggering the recognition mode in decision-making and asymmetric evaluation of the investment options. In the meantime, calculation decision mode was found to dominate the reasoning about the project in a foreign location and was also found to be the main motivating factor behind investment decisions. Empirically, this means that the financial returns on local investments might be underestimated because these are not systematically compared to financial returns on foreign projects.

In summary, the findings of the dissertation demonstrate improved economics of renewable energy projects although this does not lead to the conclusion that the renewable energy markets can be self-sustainable. If investor diversity is to be preserved, deployment policies still have their role to play in supporting renewable energies. Furthermore, there is also a role for policies to facilitate barrier removal, which can be important for the advanced stages of renewable technologies diffusion. In particular, there are still policies supporting fossil fuels and misleading investment decision-makers. Furthermore, there are discussions around self-consumption regulations in several countries, which may or may not end up as additional barriers for development of self-consumption. Despite this, it is important to note that it is not only policies that affect the investments in renewable energy, but also investor cognition aspects. While some of these aspects may be addressed by policy-makers via establishing clarity about climate and energy goals, other aspects, such as institutionalized beliefs and decision modes, are out of the policy scope and may only be addressed by company managers if deemed necessary.

Ultimately, the three papers of this dissertation make theoretical and empirical contributions to the literature on energy policy, energy investment and finance, and business and management literature about the role of policy, project economics, and investor cognition for investments in renewable energy under uncertainty.

VI. Overall limitations

This research on investments in renewable energy under uncertainty is subject to a number of limitations, which represent useful starting points for future research. While a number of paper-specific limitations are listed in each paper, there are a few general limitations, which I would like to list here.

First, the findings of the three papers are based on a relatively small number of cases. In the first paper, these are the three country cases. Further research could extend the scope of the policy role investigation to solar photovoltaic markets in other countries, with different stages of solar PV diffusion. In the second paper, these are the twenty project investment cases in Switzerland, Germany and Italy. Further research could benefit from extending the scope of the analysis to wind and gas projects in other countries, provided that there is data availability for such analyses. In the third paper, the findings are based on face-to-face interviews with twelve investment managers from Switzerland. While this small number of interview participants is compensated by the broad scope of the collected qualitative data, which is in line with qualitative methodology, further research could validate the obtained findings on a different or a larger sample of investors, potentially a sample in another country.

Second, access to data has been a challenge for the quantitative/financial evaluations of business models in the first paper and projects in the second paper. Improved access to self-consumption data patterns for different countries could be a starting point for exploring the interactions between self-consumption business models and energy policy in more detail. Direct access to the company data, and in particular, forecasting data, could benefit further research on expectations and reality of the returns on different energy projects.

Finally, the qualitative research, and in particular the third paper of this thesis, is potentially a subject to researcher's bias, associated with experimental design and the interpretative nature of the coding process. The potential impact of this bias was minimised by discussing the coding strategy and coding results between co-authors and during two meetings with the research team of the Chair for Management of Renewable Energies. Nevertheless, there might be variables affecting the decision-making process of the location choice that remained unobserved. Further research could test and extend the validity of the findings on an investor sample in another industry or country.

Curriculum Vitae

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