SCCER CREST

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Energy funding programme
Swiss Competence Centers for Energy Research

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Indicators of innovation: Empirical insights into activities, challenges and strategies of Swiss energy sector start-ups

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Indicators of innovation: Empirical insights into activities, challenges and strategies of Swiss energy sector start-ups

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ABSTRACT

Entrepreneurial activity can be seen as a signal for opportunities opening up in a changing market. This working paper covers the progress to date in developing an understanding of the activities, challenges and strategies of start-ups in the Swiss energy sector. The study, has compiled a list of 77 active start-ups in the heat and electricity fields who are contributing to four distinct challenges relevant to the national Energy Strategy 2050 goals: increasing renewable energy production, reducing energy demand, decreasing system complexity, ensuring availability of energy. So far, 14 interviews were held with selected start-ups in order to cover all of the four areas and varying customer segments, from within the energy business to end users. These interviews were conducted to specifically qualify the value proposition and current activities of the firms, as well as internal and external challenges that they faced during their development. Nine distinct challenges were identified that are specifically relevant to the energy sector. These, e.g., refer to customer awareness, possible channels for acquisition, access to finance and building legitimacy as a new entrant. Furthermore, this working paper also presents ten strategies that helped these start-ups to overcome the stated challenges. The report concludes with a number of recommendations for future research on energy entrepreneurship and to promote entrepreneurial activities in the Swiss energy sector.

CONTENT

1. Goal of the Study

1.1. Background

1.1.1. SCCER CREST

This paper represents the 2014 milestone ("empirical study to assess barriers and drivers for entrepreneurial initiatives in the energy sector") of the subtask "energy entrepreneurship and foresight" of work package 1 in SCCER CREST[1]. Work package 1 addresses the role of firms and regions in the energy transition, including innovation, new business models, investment, regional development, and social acceptance of new technologies. The subtask "energy entrepreneurship and foresight" is dedicated to highlighting effective practices of entrepreneurial strategizing and foresight that enable incumbent firms and start-ups in the Swiss energy sector to become active influencers and shapers of their business ecosystem under conditions of high uncertainty.

1.1.2. Study Overview and Focus

A very general conception of *entrepreneurial initiatives in the energy sector* comprises all activities that exploit opportunities arising from the social and legal changes currently within the energy system. However, such a conception is too broad to guide the design of a specific study. Thus, this study focuses on start-up driven initiatives that may contribute to a transition towards a more sustainable energy system. This (still broad) issue was broken down into two more specific tasks, which feed into the subsequent work on SCCER CREST at the ZHAW Center for Innovation and Entrepreneurship, see Figure 1.

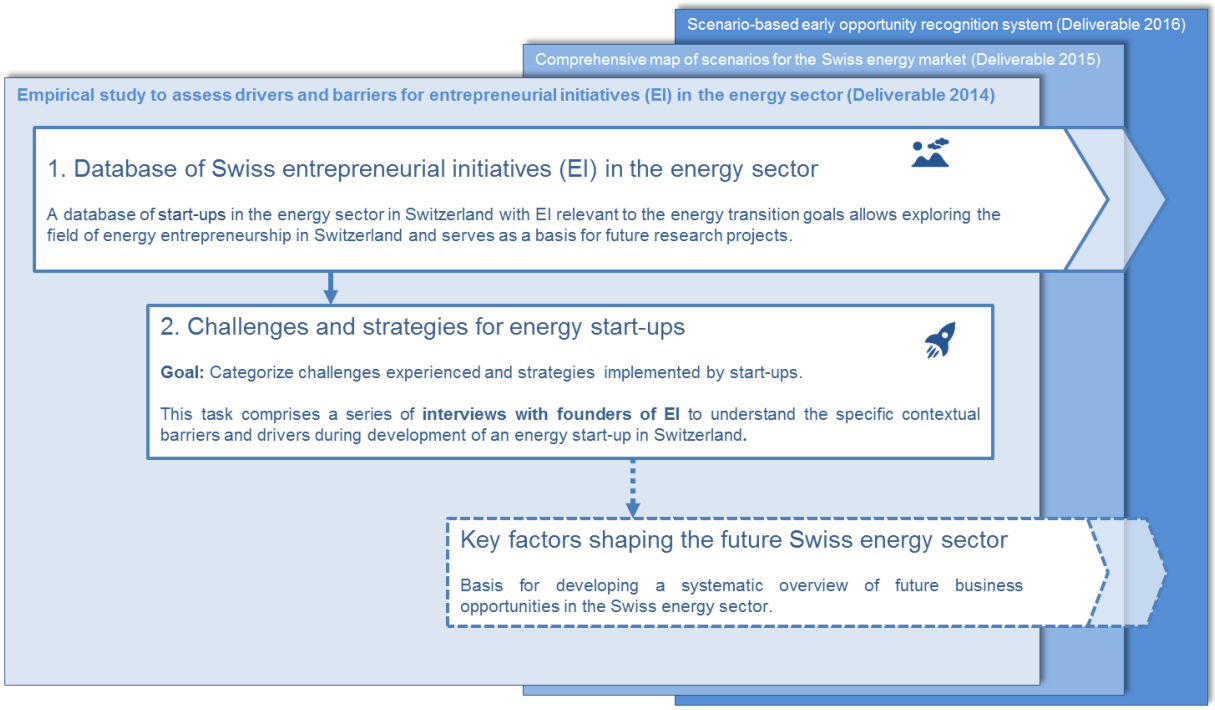

FIGURE 1 OVERVIEW OF THE TWO TASKS OF THE CURRENT RESEARCH ACTIVITIES AND NEXT STEPS FOR SCCER CREST AT THE ZHAW CENTER FOR INNOVATION AND ENTREPRENEURSHIP.

[1] That is the Swiss Competence Center for Research in Energy, Society and Transition (website: http://www.sccer-crest.ch/)

1.2. SPECIFIC AIMS OF THIS REPORT

In line with the focus outlined above (see Figure 1), this working document has the following aims: (i) provide an overview of Swiss landscape of energy sector start-ups, (ii) provide an empirically-based overview of challenges Swiss energy sector start-ups are facing and the strategies they use to overcome them, and (iii) act as a stepping stone for further research activities at the ZHAW Center for Innovation and Entrepreneurship.

2. INTRODUCTION

2.1. ENTREPRENEURIAL OPPORTUNITIES IN THE ENERGY SECTOR

2.1.1. THE CURRENT SWISS ENERGY SYSTEM

Energy has become more and more critical as a fuel for and catalyst of socio-economic development. However, the provision of energy is tied to long-lived, capital intensive infrastructure for production, conversion, storage and transportation, which results in a high inertia of the energy system. In Switzerland, this is particularly pronounced for electricity: while large parts of the oil and gas value chains are outside the country, Switzerland has a long tradition of domestic electricity generation, mainly from hydropower and, since the 1970s, also from nuclear power. This has led to a stable and specialized regime (Geels & Schot, 2007) ever since (for an overview of key elements and players of the current Swiss electricity regime, see Table 1).

TABLE 1 OVERVIEW OF THE SWISS ELECTRICITY SUPPLY CHAINS AND ITS MAIN ACTORS

Supply chain stage	Description & incumbents
Production	The major share of electricity in Switzerland is produced by only a few large producers, primarily Axpo, Alpiq, BKW, EWZ, whose main shareholders are the Cantonal governments. While some of those firms that produce electricity have a retail arm, the largest sell electricity on the domestic and international markets. At the same time, much of the electricity consumed by Swiss households, business and industry is imported from Switzerland's neighboring countries – especially in winter, when hydropower production is lower and demand higher than the annual average.
Transmission	The Swiss transmission grid is owned by the national transmission system operator TSO Swissgrid. The cost for transmission and the system services (such as ensuring adequate operating reserve) are passed on to the consumers via electricity tariffs.
Distribution/Retail	The distribution of electricity to consumers is done by a large number (500+) of local retailers that have between less than one to hundreds employees (in FTE). While some of them produce electricity as well (particularly the city utilities, such as EWZ or IWB), most of them are pure re-sellers of electricity which they buy either from Swiss or European producers. Most of the retailers also provide other utility services (water, gas, etc.) and own the local grid (the profit yields are regulated).
Trading	Some of the larger producers and retailers have a trading division to participate in the domestic and European electricity market.
Consumption	Consumers of small electricity volumes hold contracts in a fixed tariff system, i.e. they may not choose their retailer. Only since 1 January 2009, customers with an annual consumption of more than 100,000 kWh can freely choose their electricity supplier.

2.1.2. The role of start-ups in the ongoing Swiss energy transition

Shifts in the sociotechnical landscape may create stress on the current standing regime. Depending on the magnitude of the pressure to change, the flexibility of the incumbents, and the maturity of the niche actors, such as start-ups, different types of transitions may occur to integrate these shifts (Geels & Schot, 2007). Currently, the landscape pressure on the Swiss energy regime is considerable. Internationally, technology research and development play an important role in making renewable energy installations competitive compared to conventional fossil-fuel sources. Specifically, solar, wind and biomass sources have grown in economic viability and social acceptance. These, in combination with large governmental subsidy programs, have led to massive growth in renewable energy use in the last couple of years (Kaufmann, 2014). What is more, technologies and concepts from the ICT sector (e.g. "smart" devices or data mining algorithms) open up a large space of opportunities for new offerings to energy consumers and for increasing the efficiency of the energy system management. Domestically, the main pressure to transform the Swiss energy sector comes from the political arena. Since the Fukushima nuclear power plant meltdown in Japan in 2011, the national government has re-established the strategy for energy provision in Switzerland to slowly phase out nuclear power. Titled "Energy Strategy 2050" (ES2050), specific objectives in renewable energy penetration and energy efficiency improvements has put pressure on the existing regime and thus opened up gaps for innovation. A first "legislative package" with a variety of legal changes to support the ES2050 is expected to become effective in 2016. Additionally, market liberalization is intended to come for the small electricity consumers as well. It is planned for 2018 and would change the role and business models of companies active in energy distribution (mainly local energy utilities)[2].

Before the backdrop of this shifting landscape start-ups can play an important role to promote and support the ongoing energy system transition (Wüstenhagen & Wuebker, 2011). Particularly when it comes to the commercialization of new energy technologies, start-ups may capture entrepreneurial opportunities or provide niche innovation to the current regime players (Farla, Markard, Raven, & Coenen, 2012; Grubler, 2012; Santos & Eisenhardt, 2009). The intensity of entrepreneurial activities by start-ups can therefore serve as an indicator for where in the system innovation is happening and – in contrast – where it is not.

2.2. Entrepreneurship research and the specifics of the energy sector

There exists a large body of scientific literature that – empirically and theoretically – analyses barriers and drivers for entrepreneurial activities and the many challenges that start-ups face in their founding and development processes on various levels. This includes personal traits of entrepreneurs (such as willingness to take risk of self-confidence), internal challenges of young ventures (such as mobilizing resources or simply finding an appropriate location for the business), and external market forces and policies that aim at fostering innovation (Acs & Audretsch, 2010; BFE, 2014; Dickel & Andree, 2011; Fueglistaller, Müller, & Volery, 2008; Kaplan & Warren, 2010; Wajid & Jain, 2013). While much of the insights of these studies apply to energy sector start-ups, the specific characteristics and challenges for entrepreneurship in the energy sector are not yet well understood (Wüstenhagen & Wuebker, 2011) and research aiming at identifying the energy-specific barriers and drivers for entrepreneurial activities both from incumbents and start-ups is limited.

2.3. Research Questions

One key way of addressing that lack in research on energy entrepreneurship is to empirically study energy-sector start-ups. However, while there are several well-monitored and compiled lists and portals containing start-ups in the cleantech sector, these do not cover all energy sector start-ups. For example, entrepreneurial initiatives addressing behavioural change around energy efficiency or 'green' energy marketing are usually left out of these lists. Hence, a comprehensive overview of energy sector start-ups in Switzerland is still missing.

[2] http://www.nzz.ch/schweiz/vollstaendige-liberalisierung-auf-2018-geplant-1.18399761

Thus, this working paper addresses the following specific research questions:

1. What are the characteristics of Swiss start-ups in the energy sector?
2. What specific challenges impact the development and commercialization of Swiss energy sector start-ups?
3. What are the strategies used by Swiss energy sector start-ups to overcome internal and external challenges?

3. Study Procedure

3.1. Overview of Swiss landscape of energy sector start-ups

As illustrated in Figure 1, the first task covers the identification of the start-ups acting in the Swiss energy sector.

3.1.1. Defining the energy sector

Energy has infused almost all aspects of modern life, including industrial production, healthcare or leisure activities. What is more, the energy system does not simply consist of the physical electricity, oil and gas supply chains but comprises a variety of different coupled infrastructure systems, markets, regulatory frameworks and actors. Hence, one challenge when analysing energy sector start-ups is that there exists no single and clear-cut definition of what constitutes the energy sector. As a consequence, for the scope of this project a functional definition was chosen, which links to the specific energy policy goals of the Swiss ES2050 that stand behind SCCER CREST. Accordingly, the energy sector comprises all market actors that directly address one or several of the following energy policy challenges: i) substituting fossil fuel with renewables, ii) reducing energy consumption, iii) reducing transaction complexity, and iv) ensuring energy availability.

These four challenges are subsequently referred to as *impact areas* and provide the reference frame that defines the 'energy sector' in this study. The first two impact areas directly correspond to the main quantitative goals of the ES2050, which are increasing domestic renewable energy production and reducing domestic energy consumption. The others are two key challenges that follow from the pursuit of these two main goals. First, by the development of new energy markets (e.g., a liberalized electricity market for residential consumers, the creation of an efficiency market by the introduction of saving obligations for energy suppliers, or the more widespread offer of "green" electricity products) and of new technological possibilities (e.g. allowing households to become so-called "prosumers"), the energy system becomes ever more complex. This creates a demand for technologies and services that reduce this complexity for the different market participants. Second, the increase in decentralized, stochastic power production (mainly wind and PV) presents additional challenges for, as well as the potential for a new conception of, ensuring grid stability and energy security. While the requirement for supply security remains relevant, management options focus on both creating flexible integrative technology to accommodate more renewable production and working with customers to achieve awareness around absolute consumption patterns (i.e. making the consumption itself more flexible). For an overview of the impact areas, see Table 2.

TABLE 2 DEFINITIONS OF THE 4 IMPACT AREAS THAT PROVIDE A FUNCTIONAL DEFINITION OF THE ENERGY SECTOR FOR THE SCOPE OF THIS PROJECT.

Impact area	Definition
1. Substitution of fossil fuels with renewables	With the constraints of reducing carbon emissions and phasing out nuclear power, a considerable increase in the use of energy from renewable sources within Switzerland is foreseen by the ES2050.
2. Reduction of energy consumption	Specific requirements for a reduction of both the overall energy and the electricity demand by large and small consumers in Switzerland have been set by the ES2050.
3. Reduction of transaction complexity	Energy provision in Switzerland and elsewhere is becoming increasingly market-based. This brings about an increased complexity for all (potential) energy market actors. For example, electricity consumers are faced with new choices of where (from a utility, market place, neighbor, etc.) and what quality (standard mix, grey, ecological, etc.) of energy they buy, or may produce (or even "prosume"). This creates an information gap that limits the potential for an efficient functioning of energy markets.
4. Ensuring availability of energy	As a result of more decentralized renewable power production, ensuring a balance of supply and demand takes becomes more challenging. The energy system of the future will require more flexibility and thus incorporate a variety of novel elements, such as smart grids, virtual power plants, storage (and release), and increased ability for load shifting (e.g. through intelligent household appliances).

3.1.2. Sample selection

A compilation was made of start-ups acting in the Swiss energy sector. This compilation is based on a systematic analysis of over 40 publicly available websites that contain lists of start-ups (such as start-up monitors, the members of Swiss technoparks and incubators, entrants for start-up competitions, participants of CTI venture courses, etc). Furthermore, some firms were also identified through expert feedback and private personal networks. Apart from still being operational in 2014 and having to address at least one of the four impact areas (as defined in the above section), companies had to meet the criteria shown in Table 3 in order to be included in the list.

TABLE 3 CRITERIA FOR THE SELECTION OF SWISS ENERGY SECTOR START-UPS CONTRIBUTING TO ES2050 CHALLENGES.

Criterion	Reasoning
Founded since 2000	While the age of a venture is no reliable indicator of its phase of development, companies older than 15 years are assumed to no longer be in a start-up phase, but rather have grown into a niche market..
Based and active in Switzerland	While foreign companies also play a relevant role in shaping Swiss energy markets, this study focuses on the potential for start-ups to develop in Switzerland.

No advanced component technology producers	While the development of specific components (such as an energy efficient microprocessor) may certainly support the goals of the ES2050, it is neither directly driven by it nor can its producer generally be considered in the energy sector. As a consequence, these firms are usually neither exposed to the energy sector's strong regulatory frame nor to the transition of the energy system in general.
Non-mobility	While there exist strong linkages between the value chains of mobility and of heat and electricity (a shared primary and secondary energy resource), they are structurally very different. As a consequence, start-ups in the mobility sector were excluded from the analysis to limit overall heterogeneity of companies on the list.

3.1.3. Data analysis strategy

Apart from collecting their names, location, founding year, contact details (if available) and a short description of their activities, all listed energy sector start-ups were characterized according to three different parameters. This characterization was based on the self-defined activities of these firms as described in the public space (i.e. primarily their own websites). The parameters used were the following:

- Their **products** were classified as being either a technology, a service, or a technology-service combination. The companies are defined distinctively by only one of these product types based on their current market offer.
- The main **customer segments**, as defined by where the revenue is created, are defined at 2 broad levels (see Table 4 for examples). The first includes energy consumers, both small, i.e. households, and large, i.e. businesses and industry. The second group of customers includes those that do not have a relevant consumption-based motivation to purchase the company's product, but are active businesses in the energy value chain, such as renewable energy producers, utilities, and grid operators, or outside of the energy sector, such as investors, communities, and building owners. A company may serve more than one (i.e. up to all four) customer segment(s).
- Where the **impact** takes place refers to the four impact areas defined above (see section 3.1.1). The start-ups are typically only impacting one of these segments in their development phase, thus each company is distinctively categorized into one of the four.

TABLE 4 EXAMPLES OF CUSTOMER SEGMENTS FOR SWISS ENERGY START-UPS

Customer segment	Examples
Energy sector Non-consumer	Energy producers, grid operators, utilities
Non-energy sector Non-consumer	Investors, installers, communities, architects
Large consumers	Industry, business
Small consumers	households

3.2. CHALLENGES FACING SWISS ENERGY SECTOR START-UPS

Task 2 is concerned with a more in-depth understanding of the development process of energy sector start-ups, the challenges these companies have faced, are currently facing and might face in the future, as well as the strategies they have chosen to meet these challenges. This information cannot be gained from company websites alone. Thus, to get a more detailed, empirically substantiated picture of actual activities, and the specific past, present and future challenges of Swiss energy sector start-ups, structured interviews with founders of these start-ups were conducted.

3.2.1. SAMPLE

Based on the full list of Swiss energy sector start-ups (see section 3.1), a shortlist of 30 companies was compiled. The goal in compiling that shortlist was to (i) represent the extent of the landscape of Swiss energy sector start-ups and (ii) to include those that have a particularly innovative activity. All these companies were contacted by e-mail between October and December 2014 to ask whether one (or several) of its founders would be willing to participate in an interview. Consequently, 14 semi-structured interviews with founders of start-ups active in the Swiss energy sector were conducted between November 2014 and February 2015.

3.2.2. DATA COLLECTION

The semi-structured interviews followed an interview questionnaire. Its outline is presented in in Table 5. The interviews were of an exploratory nature, i.e. the goal was not to test any previous hypotheses or theoretical models on the challenges facing these start-ups. Instead, the focus lay on thoroughly understanding the activities of the selected companies through their development, the backgrounds of the founders, and their individual views on what were, are and may be future challenges to a successful development of the company.

During the interview, which lasted between 60 and 120 minutes, extensive notes and an audio recording were taken. In all but one of the interviews two researchers were present. For two of the companies, not one but two of the founders were present at the interview. The interviewees did receive a small gift for their participation (usually a bar of chocolate), but no financial incentive.

TABLE 5 STRUCTURE OF SEMI-STRUCTURED INTERVIEWS WITH SWISS ENERGY SECTOR START-UP FOUNDERS

Part of the interview	Key issues to be discussed
1. Introduction	• Introduction of interviewers • Study background
2. Background of founder	• Educational background and work experience of founder • Motivation(s) of founder to start a venture
3. Start-up overview	• Key innovation/idea behind the venture • Activities of the venture • Team & structure of start-up
4. Development process of start-up	• Development process of the start-up (idea, realization, current situation, future perspectives) • Focus on challenges encountered and lessons learned
5. Entrepreneurship in the Swiss energy sector	• Opportunities and challenges facing the Swiss energy sector • Current and future trends

3.2.3. DATA ANALYSIS STRATEGY

The interview results were compiled in order to succinctly present the categories of factors relevant to the development and operation of energy sector start-ups in Switzerland. Due to the lack of an empirically based framework for analysing challenges and/or strategies of the start-ups, using a predefined set of categories was not suitable, as it might have masked important insights contained in the cases (Durand & Paolella, 2013). What is more, the focus of the analysis of the challenges and strategies was based on the interviewee's understanding of the reasons for their successes and failures, and their experiences and lessons learned throughout the start-up process (i.e. idea development, commercialization, and scale-up).

In order to structure and synthesize the interview responses, a set of challenges and strategies of Swiss energy sector start-ups was developed in an inductive (i.e. not theory-guided but bottom-up) and stepwise process: First, after about eight interviews were conducted, all challenges and strategies mentioned by the interviewees were identified for each start-up. General entrepreneurial challenges that can be found in any start-up, regardless of the sector it is active in (e.g. exit of a business partner), were excluded. Then, all similar challenges and strategies were grouped together. After each additional interview the list of challenges and strategies was critically examined and – if necessary – expanded or adjusted. Finally, using the complete list to determine which start-ups had similar and different experiences, comparisons could be made and insights gained on the Swiss start-up landscape.

4. RESULTS

4.1. THE ENERGY ENTREPRENEURSHIP LANDSCAPE IN SWITZERLAND

77 start-ups were found that are active in the Swiss energy sector. Figure 2 shows the distribution of the firms across the four customer segments (as described in Table 4), product offers (service, technology or both) and impact areas. About 80% (N=63) of the start-ups were founded since 2008, and there is an equal share of individual technology and service offers (each accounting for 44%, N=34).

It is clear that the majority of the start-ups are working within the renewable energy production value chain (graphs A, B in Figure 2) and a large proportion of them consider utilities and large project developers as their primary customer segment (graphs A). As expected, this impact area has the majority of the technology offers in the form of renewable energy production technologies (wind or solar) at various scales depending on the customer. There are less products offered directly to energy consumers (graphs B), and thus there is a notable decrease in start-ups aimed at creating revenue from small and distributed energy consumers (i.e. households).

As energy efficiency is directly relevant to the consumer segment, many start-ups have positioned themselves with service and technology offers directly for the two energy consumption segments (graphs D). These firms are typically offering smart home meters (specifically to small consumers) or sustainable behavior/ consulting services (typically for larger consumers). Very few firms active in energy efficiency are looking to the non-consumer segment or utilities as a customer (graphs C). Those that do are focusing on providing a link, or mediation, between the utility and the end-consumer and using the utility as a customer aggregator, and therefore are primarily service oriented. Service offers are mainly consulting services for behavior change, system optimization, or urban planning.

The offer across all customer segments to decrease the complexity of the energy system is always service oriented (graphs E, F). The non-consumers are primarily consulted about their renewable energy development projects (graphs E) and the consumers are offered online platforms to support the purchase of (mostly renewable) electricity products (graphs F).

Finally, start-ups active in the supply security area have a range of offers from storage technologies to software tools for balancing the grid. Their main customers are grid operators regulator (graphs G) that need to better

be able to model the effect of stochastic electricity production from wind and solar on the electricity grid. On the consumer side, there are only a few start-ups offering storage technologies or consulting services to residential or industrial con- or prosumers (graphs H).

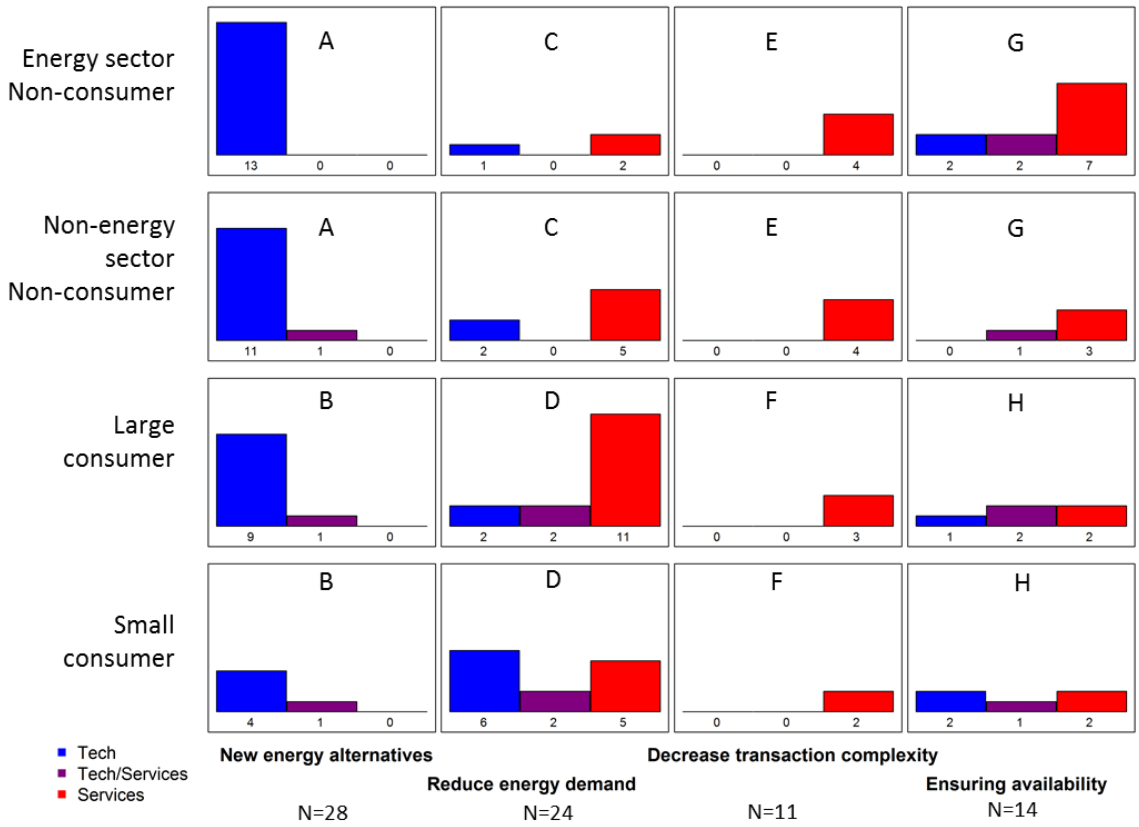

FIGURE 2 IMPACT AREAS OF 77 SWISS ENERGY SECTOR START-UPS VS. OFFERS VS. CUSTOMER SEGMENTS (NOTE: START-UPS MAY HAVE MORE THAN ONE POSSIBLE CUSTOMER SEGMENT)

4.2. Analysis of selected energy start-ups in Switzerland

4.2.1. Overview

The characteristics of the interviewed start-ups in **Fehler! Verweisquelle konnte nicht gefunden werden.** show that they cover a broad portion of the energy sector, however some gaps remain.

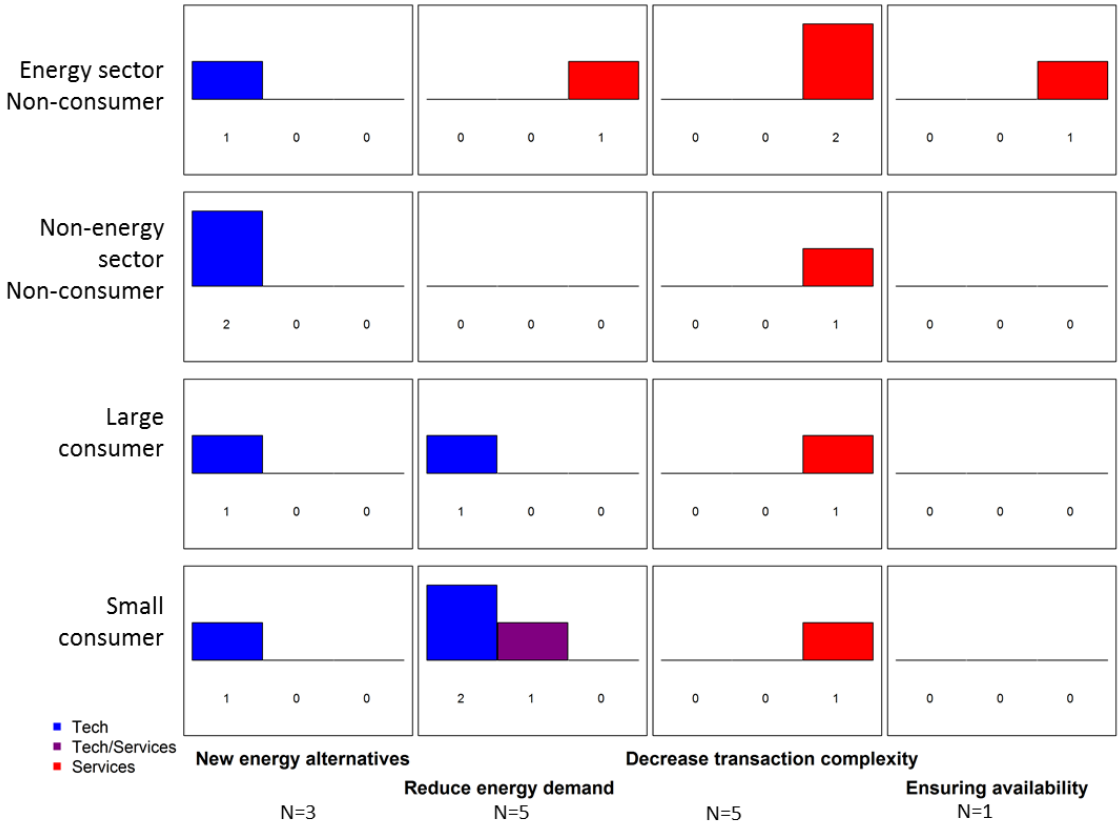

FIGURE 3 IMPACT AREAS OF THE INTERVIEWED START-UPS (N=14) OFFERS VS. CUSTOMER SEGMENTS (NOTE: START-UPS MAY HAVE MORE THAN ONE POSSIBLE CUSTOMER SEGMENT)

The analysis of the interviews protocol of the 14 selected Swiss energy start-up revealed a variety of different challenges these companies have faced in the past, are currently facing, or will in the future. They also revealed a huge diversity of strategies these companies have (actively or passively) adopted to overcome these challenges. Apart from the specific challenges and strategies employed by the start-ups, the following is a list of general observations and insights concerning the sample of the start-ups that were interviewed:

- While most of the start-ups already have paying customers for their product or service, all but one still currently rely on external financing – be it their own savings (or that of friends, fools or family), project financing, angel investors, crowdfunding campaigns, start-up prizes or subsidies.
- A clear majority of the interviewees did not reveal any plans to sell their stakes in the company in the years to come, or even to aim for an IPO as an exit strategy. Rather, most have expressed that their goal is to build up a long-lasting organization.
- Three of the technology manufacturing firms are already producing at a large scale with equipment and the necessary space for production, and have between 20 and 40 employees.
- Seven of the start-ups are primarily software firms, and have less than ten employees.
- Four of the firms already have operations outside of Switzerland. Of the others, many are considering to move into international markets within the next 5 years
- All but two of the start-ups have links to research institutions but only four of them have developed directly out of a university research program (such as a PhD thesis).
- Three of the firms have their origin in corporate research and development programs that were continued as independent organizations by either involved researchers or managers.
- When asked, only about a third of the interviewees saw their firms as particularly exposed to the legal/regulatory framework (and changes thereof) for their businesses.

4.2.2. Specific Challenges to entrepreneurial activities in the Swiss energy sectors

Although the interviewed start-ups are quite different, they display some similarities in terms of challenges they have faced and the strategies they have chosen to address them. Table 6 shows a compiled list of specific challenges for Swiss energy-sector start-ups.

TABLE 6 CHALLENGES OF ENERGY START-UPS

Challenge	Description
Potential customers are not aware of value proposition	Many large customers (>100 MWh) are not yet participating in the liberalized electricity market (27% as of 2014[3]), possibly due to the long investment cycles and residential consumers often do not recognize the potential to improve their energy efficiency because of high level of energy security and low consumer energy prices.
Potential customers struggle with understanding the value proposition	Both large and residential energy consumers may struggle with how the renewable energy market functions, including regulation implications, market mechanisms, electricity mixes, or paying for the ecological added-value of renewable energy.
Long investment/ contract cycles client-side as entry barrier	Power generation units (be it PV cells or a hydropower plant) have life cycles of decades, and heating and electrical systems in households or factories last 10 – 20 years. Thus, the rapid implementation of any new technologies, such as smart metering systems, requires an add-on installation. Additionally, many energy producers and retailers seek to negotiate long-term contracts. Market entry is thus time sensitive.
Energy technology development and manufacturing are capital intensive	Developing a prototype, testing and scaling-up to commercialization requires significant investment. A start-up firm has to demonstrate the potential of the technology through real tests but also acquire large financing to support this proof of concept stage.
Incumbent companies act as gatekeepers	Within the strongly regulated, inert, and largely conservative energy system, the incumbents play a critical role by controlling access to customers. Many potential customers of start-ups rely, e.g., on energy utilities as intermediaries, which limits the direct interaction between the firm and the end user of the service or product.
Key actors are risk averse	Due to the societal importance of a reliable supply of energy and the inertia of the energy system (e.g. large infrastructure-related investments are neither decided upon quickly nor often), many key actors, such as utilities, investors, public administrations, and regulators are very risk averse, thus not open to innovative ideas of start-ups.
Future political and legal situation is uncertain	The energy sector is strongly regulated and very dependent on the national and regional energy policy framework. Changes can occur quickly, as the decision to phase out nuclear power as a consequence of the Fukushima plant failure has demonstrated.

[3] https://www.news.admin.ch/message/index.html?lang=de&msg-id=51090

High concern for data security and privacy	Many firms are offering a mediation service between the supply (B2B) and demand (B2C) of electricity and thus are compiling market relevant data from consumers, producers and investors, amongst others. Customers may be particularly sensitive due to the essentiality of energy. A reputation of trust and ensuring confidentiality is not a given for a new firm who may not have the track record, nor the internal structures for addressing privacy concerns.
Building legitimacy in a conservative environment	The firms without a strong network, or partner, cannot establish their reputation for quality in order to gain customers and establish a track record. In the current energy value chain, vertically integrated incumbents, particularly utilities, control many of the business interactions and opportunities.

The interviewed start-ups had a primarily internal viewpoint when looking at challenges and strategies of their past development. Many general entrepreneurial challenges were faced by the start-ups analysed, such as distribution of shares amongst founders, lack of knowledge about or access to funding sources, and the time and cost intensity of scale up from the lab to the marketplace. However, these were not analysed in further detail.

4.2.3. Strategies to overcome challenges

As firms face the specific challenges presented above, the self-reported strategies for success (often reported as lessons learned) give insight into the prioritization of problems and the form of solutions implemented. Here the categorization is structured following the Business Model Canvas building blocks (Osterwalder, Pigneur, & Clark, 2010) wherein the different aspects of the business address specific types of challenges. This structure is chosen as it covers the aspects where the firm can take specific action. Table 7 highlights the main strategies employed by the start-ups that were interviewed. Note that not all canvas building blocks are included, as these did not explicitly develop out of the results.

TABLE 7 STRATEGIES IMPLEMENTED BY THE FIRMS IN RELATION TO THE BUSINESS MODEL FIELD

Business model field	Strategy	Description
Value proposition	Competitive quality of Swiss made products	The offer (product or service) is marketed with an emphasis on the Swiss production due to the reputation for quality, durability, and high performance in the international context.
	(Re)orientation of value proposition regarding energy topic(s)	The economic arguments for energy efficiency and potential business opportunities in renewable energy development can add to the value of the offer. However, in a complex, low margin market, such as that of electricity, the offer may need to be reoriented to highlight different value proposition (e.g. convenience, carbon emission reduction, status, better information on processes or customers, alternative market segment, etc.).
	Application potential outside of the energy sector	Apart from having the potential for mass distribution within its target market, the offer can be adapted for different market segments outside of the energy value chain. This can reduce risk (such as the regulatory uncertainty) associated with energy markets.

Key activities	Running pilot tests for proof of concept	Without a track record, the start-ups must demonstrate the value of their offer through pilot tests and proof of concept trials with a small trusted customer base over a longer time horizon. As incumbents dominate the energy value chain, start-ups developing in specific niches may have to demonstrate particular added-value and legitimacy.
	Use already available processes and components	A company can take advantage of multi-faceted competences contained within the management processes, team skills and product value proposition, for efficient adaptation and positioning without a large time and cost investment.
Key partners	Capturing strategic financing and partners	With the energy system being very complex, investors and partners do not only bring capital but can also support with their know-how and established networks. These may offer new channels to customers and other partners that may be less visible.
	Maintaining link to academic research	The connection between an academic institute and the start-up can be a form of incubation for a business idea. Additional advantages include the further advancing of the offer using established infrastructure, access to CTI funding, and developing a track record within the high tech energy market.
Key resources	Outsourcing when possible	Cost minimization can occur when key activities can be outsourced. In addition to administrative activities, this may also be applied to energy specific processes or components, such as a case for a smart plug, or cloud computing power needed for calculating heavy simulations.
Channels	Connecting through intermediaries to customers	If the customer segment is a large, fragmented and low margin group, such as that of end-consumers, accessing this market can be aided using aggregators, such as utilities, or multiplies, such as installers.
	Visibility through media presence	New firms may lack marketing capacity, thus start-up competitions, (online) media or support by trusted institutions can bring crucial visibility in a competitive and often non-transparent market.

5. Discussion

5.1. The landscape of energy entrepreneurship in Switzerland

The analysis shows that there is a large number of energy start-ups in Switzerland that all address a direct or indirect challenge of the ES2050. The variety of their activities reflects both the extent of the ongoing transition of the Swiss energy system, as well as the need for innovation, caused by regulatory changes, dwindling profit margins in the traditional energy value chains and new emerging markets (such as the growing demand for

energy efficiency services and flexible operating reserves). That said, the number of energy sector start-ups is still much lower than those active in other sectors, such as ICT, Medtech & Diagnostics, or Biotech & Pharma[4].

This may simply be due to the lower number of qualified specialists that can potentially become energy entrepreneurs. Only the Fukushima accident and the subsequent decision by the Swiss government to phase out nuclear power in summer 2011 have pushed the energy issue to the forefront of university research[5] and education in Switzerland. Thus, the number of energy sector start-ups can be expected to increase in parallel with the growing number of energy-affine BSc, MSc and PhD graduates, who have the know-how to develop innovative technical and non-technical solutions to the challenges facing the energy sector. In contrast, the higher number of start-ups in other sectors may be due to the higher activity of incumbent companies in promoting and absorbing innovation from outside the company. Many large ICT or pharmaceutical companies have identified innovation as the key to remain competitive internationally and, as a consequence, have successfully managed to create innovative ecosystems that provide a fertile ground for start-ups (the most prominent being Silicon Valley). Meanwhile, many Swiss energy companies are only slowly adapting their traditional business models and any innovation activities they pursue are purely internal. This may discourage a considerable number of potential entrepreneurs to start a venture in the energy sector.

5.2. Challenges and strategies of Swiss sector energy sector start-ups

The interviews with the founders of 14 energy sector start-ups have revealed that many of these firms have faced (and still are facing) a range of typical entrepreneurial challenges (such as a shortage of financing or the question of how to distribute shares among its founders). But due to the large heterogeneity of these start-ups there exists no universal set of energy specific challenges that applies to all of the firms equally: The challenges of a company that produces a novel type of PV cells may more resemble those of a manufacturing company (e.g. raising the capital necessary to set up a production line with a considerable workforce to even become operational) than those of a green energy trading platform that must gain the trust of the different market participants. The only external influences that affect most of the firms are different aspects of energy prices (e.g. electricity production cost, wholesale prices, price fluctuations etc.). But even when asked directly, only few of the start-up founders perceive these external market factors as challenges for their businesses. For example, changes in the regulatory framework (such as regulations on the carbon price or feed-in-tariffs) were only rarely mentioned explicitly during the interview. This stands in contrast to the widespread international evidence that regulation is a key parameter in shaping the energy market (BFE, 2014). Reasons for the relative insignificance of regulatory factors may be the short lifetimes of many of the companies (i.e. many of them have not yet experienced the impacts of a regulatory change on their business), that external market factors were considered as out of the control of the start-ups, or that internal challenges simply demand all of the entrepreneurs' attention.

Another notable insight from the interviews is that challenges faced and strategies implemented at different stages of development are tightly intertwined. Two typical examples of the interactions are shown in Figure 4 a) and b). There were many cases where a challenge was addressed by several strategies at once and – vice versa – that a strategy contributed to solving multiple challenges at once (Figure 4a). Feedback loops were also visible, (Figure 4b), where a set of strategies addressing a specific challenge ultimately produced new challenges.

[4] As an illustration, according to the Swiss Startup Monitor (http://startupmonitor.ch/start-up-directory/, date last accessed: 12.03, 2015) there are currently 513 active start-ups in "ICT", 181 in "Medtech & Diagnostics" and 139 in "Biotech and Pharma", while in "Energy & Greentech" there are only 76.

[5] For example, the SCCERS and the NRP 70 and 71 are creating an unprecedented number of energy experts that will be available to the Swiss energy markets in the years to come.

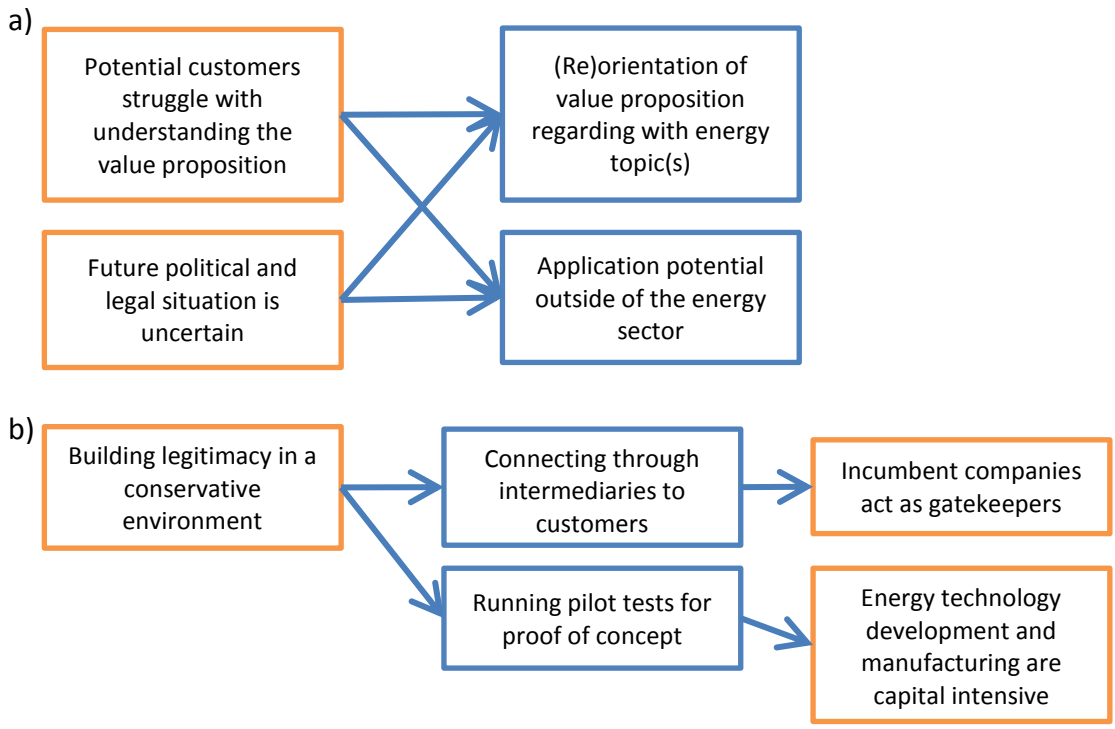

FIGURE 4 INTERACTION PATTERNS (A AND B) BETWEEN CHALLENGES (ORANGE) AND STRATEGIES (BLUE) OF START-UPS IN THE ENERGY SECTOR

5.3. CRITICAL APPRAISAL

5.3.1. DEFINITION OF THE ENERGY SECTOR

This study set out to provide a first overview of the Swiss landscape of energy sector start-ups, which raises the question of what constitutes the energy sector in the first place. This question is answered by using a functional definition of the energy sector based on the direct and indirect challenges of the ES2050 (referred to as impact areas). Thus all companies that address one of the impact areas is included. While this approach is certainly useful for the specific context of this study (which is specifically Swiss focused and part of SCCER-CREST), one has to bear in mind that in other contexts the definitions of the energy sector may vary considerably. Hence, when communicating the study results, this specific energy sector definition needs to be transparently conveyed in parallel.

5.3.2. COMPLETENESS OF THE SAMPLE

Based on the chosen definition of the energy sector this study produced a sample of 77 start-ups. While they certainly cover a significant share of what one would intuitively consider energy sector start-ups, there are a number of reasons to believe that the sample is not exhaustive. First, the boundaries of the chosen definition of the energy sector are fluid as, for example, there may be firms (mainly in ICT) that do not appear to be active in the energy sector, but whose products and services may have a considerable impact on one or several of the four selected impact areas. Second, some specific criteria used to select the companies had to be chosen for practical reasons and may be subject to change in a later stage of the project. For example, firms active in mobility have been excluded. Third, start-ups have a low average lifespan and new ones may emerge quickly while others stop their operations. This means that such a compilation of start-ups is always only a snapshot.

5.3.3. CHARACTERIZATION OF CHALLENGES FOR AND STRATEGIES OF SWISS ENERGY START-UPS

The interviews with founders of start-ups did provide a broad overview of challenges specific to the Swiss energy sector and strategies applied by these entrepreneurs to address them. However, the applied methodology does neither allow for comparing these challenges in terms of their relevance for an archetypal start-up nor for discerning the most effective strategies to cope with them. For that, more quantitative data,

e.g., on the companies' performance (or planned performance as stated in their business plans) or on the characteristics of the challenges effectively encountered would be needed and preferably a larger sample.

6. CONCLUSIONS AND OUTLOOK

6.1. MONITORING OF START-UP ACTIVITIES

Particularly if start-up activities are used as an indicator for where innovation is happening – and where it is not – a snapshot picture of activities and challenges provides only a static overview and is only part of a more practical output. It is more relevant to understand the dynamics of energy sector start-ups, including changes in the number of ventures, their fields of activities, their performances, or the sources of the invested capital. One approach to capture these dynamic developments and provide the basis for more specific research on energy entrepreneurship in Switzerland would be to establish a continuous monitoring programme of energy sector start-ups (similar to the start-up monitor operated by the University of St. Gallen, ETH Zurich and the University of Basel).

6.2. ENERGY ENTREPRENEURSHIP IS NOT JUST ABOUT START-UPS

By analysing the landscape of energy sector start-ups the study represents a first step towards understanding the ongoing innovation in the Swiss energy sector. However, these cover only a small share of all innovation activities that may shape the future energy system and contribute to meeting the challenges set by the ES2050. The current Swiss energy market – particularly concerning electricity production and the import of fossil fuels – is dominated by a number of strong incumbents. While these may be less agile than start-ups, any strategic decision by them has a high impact on the energy market. In order to better understand the role of start-ups in the national progress towards the ES2050 goals this analysis needs to be contrasted with one that focuses on the innovation activities by incumbent energy companies.

6.3. MORE INSIGHTS ON CHALLENGES, STRATEGIES AND THEIR LINKAGES NEEDED

This study draws on qualitative data from 14 explorative interviews with energy entrepreneurs. Hence, it can neither provide information on the relative importance of different challenges for start-ups in the Swiss energy sector nor does it allow for a detailed understanding of the dynamic linkages between these challenges and the set of different strategic alternatives start-ups have in order to address them. There are several ways to address these gaps in knowledge. One would be to conduct another series of interviews with energy entrepreneurs which build upon the first results and are thus more structured. These interviews would further qualify the initial list of challenges and allow for a better understanding of how different energy sector start-ups are affected by them and how they address them. An alternative would be to send a follow-up survey to all entrepreneurs that have been interviewed previously in order to complement the qualitative insights with more quantitative responses. Such a survey could also be sent to the whole sample of 77 energy sector start-ups to get a much more detailed overview of entrepreneurial activities in the Swiss energy sector. What is more, a dedicated analysis of failed energy sector start-ups may reveal additional insights into effective challenges for entrepreneurial activities in the energy sector (as opposed to perceived ones).

6.4. THE IMPACTS OF INTERNATIONALIZATION AND CONVERGENCE

The solutions to the challenges of the ES2050 may neither be delivered by domestic incumbents nor energy-sector start-ups. As energy markets and its players are becoming ever more international, it is plausible that in the future a foreign company (e.g. E.On) becomes the main electricity supplier of Swiss consumers while the majority of the assets held by now-incumbent Swiss energy companies are solar parks in southern Spain. It is also thinkable that through the convergence of energy and ICT (e.g. in the area of "smart home") a company whose core business used to be different from energy (e.g. Swisscom or Google) becomes a key provider of

energy services. Thus, one potential line of future research that draws from this study would be a comparison of the Swiss energy innovation landscape (and the functional definition of the energy sector) to that of other national and regional contexts.

6.5. PROMOTING ENERGY INNOVATION THOUGH ENTREPRENEURSHIP

Using the insights of this study as a stepping stone, a next task could be the analysis of how entrepreneurial initiatives in the energy sector can be fostered in a meaningful way, i.e. in a way that supports the transition of the energy system towards a more sustainable state. This requires identifying the different actors that may have an interest in promoting entrepreneurial initiatives in the energy sector (such as the federal government (CTI, SFOE, etc.), the cantonal governments (economic departments), techno- and innovation parks, incumbent energy companies, environmental NGOs, venture capitalists, firms active in convergent fields (e.g. ICT industry or producers of electric appliances), and many more) as well as understanding these actors' different means for doing so. These may include a variety of aspects, including the provision of investment capital, a stable regulatory framework, more education and training, lower barriers for partnerships between start-ups and incumbent firms, and developing a culture of entrepreneurship in the Swiss energy sector.

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