sustainability

Article

The Role of Experiments and Demonstration Projects in Efforts of Upscaling: An Analysis of Two Projects Attempting to Reconfigure Production and Consumption in Energy and Mobility

Marianne Ryghaug [1], Michael Ornetzeder [2], Tomas Moe Skjølsvold and [1] William Throndsen [1,*]

[1] Department of Interdisciplinary Studies of Culture, NTNU, 7491 Trondheim, Norway
[2] Institute of Technology Assessment, Austrian Academy of Sciences, 1030 Vienna, Austria
* Correspondence: marianne.ryghaug@ntnu.no; Tel.: +4793093210

Received: 16 August 2019; Accepted: 15 October 2019; Published: 17 October 2019

Abstract: There is a multitude of experimentation, pilot and demonstration projects across Europe aiming to reconfigure energy consumption and production systems. Demo-projects and experiments have been recognized as important instruments to implement sustainability transitions in practice. Transition scholars have done much to clarify how we should understand experiments and pilot projects, focusing on involved actors, what is learned, and how the knowledge is used. In this paper we study two pilot project and discuss their qualities as sites that bundle new systemic properties, technologies, regulations, business models and user practices in new ways. We discuss these cases as new configurations with promising transformative implications. The two cases studied are a Norwegian and an Austrian smart grid demonstration. Both cases represent companies that have transformed their relation to and participation in the transport system as an outcome of pilot projects and experiments. The study analyses the complexity of factors influencing the effectiveness and success of these reconfigurations in providing destabilization and change within until now relatively stable regimes.

Keywords: experiments; pilots; upscale; sustainability; transitions; smart grids; electric vehicles; transport; industry; niche

1. Introduction

To enable wide-scale integration of variable renewable energy production and to handle peak electricity demand in strained electricity grids, countless smart grid (and smart low carbon transport related) pilot projects and experiments have been set up across Europe over the last years. Working within demonstration projects and through experiments has been highlighted as important strategies for enabling sustainability transitions [1–4]. Conceptually, transition scholars have done much to clarify how we should understand experimental projects. Many have focused on involved actors, what is learned, and how knowledge generated through such projects is used [5–7]. There is, however, a need to move beyond lessons from individual cases, to understand processes of upscaling, and the potential role of demonstration projects in wider systemic transitions [8,9]. In this paper, we analyse results across two such projects in Norway and Austria to understand their effort to reconfigure the businesses and the sectors that they are part of. We discuss these two cases as sites where new system properties, technologies, regulations, business models and user practices are bundled into new configurations that may challenge the system of which they are part. Do they challenge existing regimes and to what extent can they be understood as new technical selection environments where certain technological pathways are closed? Answering these questions may help us understand how system reconfiguration unfolds in different domains such as mobility, housing and industry.

The study is based on in-depth research of two smart grids demonstration projects in Norway and Austria. A smart grid can be seen as a particular kind of innovation, i.e. a configurational technology, which means it is a system that does not consist of a single technology or artefact, but of different components that can be arranged in several ways based on the context of application [10,11]. These two particular projects can be viewed as niche experiments, defined as: "inclusive, practice-based and challenge-led initiatives designed to promote system innovation through social learning under conditions of uncertainty and ambiguity" [6]. Through comparative analysis across cases and countries, the study identifies key factors related to technology, markets and actor involvement in developing integrated smart grids solutions that work in practice. We conduct a detailed analysis of two out of nine smart grid demonstration projects studied within a project under the ERA-NET smart grids plus program. The projects involve different socio-technological configurations for energy production (PV), storage (batteries, hydrogen), mobility (EVs), consumption (smart meters, energy efficiency measures, smart charging of EVs etc.) and innovative solutions related to visualising consumption data. A key aspect of the research project has been to account for the complexity of factors influencing the effectiveness and success of these reconfigurations (including new regulations, standards, business models and user practices).

In this paper, we analyse different ways of reconfiguring energy production and consumption. This includes new ways of generating, storing and consuming energy as well as new forms of relations between the energy producers and consumers. We also probe how differences in system characteristics across the two countries affect outcomes. Improving energy efficiency and replacing fossil fuels with renewable energy are key goals for achieving sustainable energy systems. However, changing the roles of small to medium sized consumers (e.g., households and small businesses) in the future electricity system, is also part of this transition. Another key aspect is implementing low-carbon means of mobility and transport. Zooming out to observe the transformation of these domains together, we ask, what is the role of demonstration projects and experiments such as those studied here?

The remainder of this paper is structured as follows. Section 2 reviews relevant literature and develops a theoretical framework for analysis. Section 3 discusses the methodology. Section 4 presents results and compares across cases. Section 5 concludes and provides suggestions for further work along the lines of the analytical framework provided in this paper.

2. Theoretical Framework: Upscaling Literature

Processes of upscaling from pilot projects and experiments has received attention in innovation literature, and particularly within studies of Strategic Niche Management (SNM) and Transition Management [12]. These approaches focus on incremental regime changes, while highlighting that more radical innovations unfold in protective spaces such as niches that shield radical innovations from regime selection pressure such as fierce price competition [13,14]. Experiments have been described as 'seeds of change' [9]. They can be niches, or they can be conducted within a wider niche setting.

We analyse two examples where novel technologies and ways of doing things are developed within shielded spaces. They both eventually become integrated in ordinary use, practices and markets beyond this shielding. Outside the shielded space, they mobilize socio-technical resources and shape their own operating spaces through influencing infrastructural requirements, public policies and political power, as well as cultural aspects rooted in regimes. Thus, we gain insights on how experiments and demonstration projects influence the systems outside of the pilot setting.

With respect to the issue of time, a linear perspective would follow novel technology and practices through initial, shielded R&D work, then move on to an industrially shielded space before finally entering a market niche. If successful, this would lead to a reshaping of regime traits like new infrastructural requirements, public policies, political power and cultural significance [14]. However, developments seldom unfold linearly. Niche advocates tend to work in more convoluted ways to mobilise whatever resources are at hand. Thus, success or failure will depend on the character of work involved [15,16].

This is highlighted in literature on niche innovation [17], which has identified several core processes that are characteristic in transforming inventions and ideas into robust socio-technical configurations. Typically, the described processes are, (a) the articulation and the adjustment of expectations and visions; (b) the building of social networks and the enrolment of a growing number of actors; and (c) learning and articulation processes on dimensions such as technical design, user preferences, or symbolic meanings [18]. Within a multilevel perspective, such processes contribute to upscaling, i.e. the transfer of solutions from niche to regime [9]. We consider smart energy system pilots and demonstration projects, like those analysed in this paper, as niches that must provide and maintain these core processes to a certain extent in order to be successful. Activities at the niche level may influence the more stable configurations of prevailing socio-technical systems only if the activities gain internal momentum, become more visible, and therefore attract an increasing number of actors [18].

Upscaling from experiments has often been described simply as increasing the adoption rates of an innovative product over time. Socio-technical transition studies highlight that this is too simplistic, since upscaling also refers to changing social and institutional contexts, as well as growing alignment of technologies, actors and institutions [19]. Wieczorek [9] highlights that practical strategies of upscaling can include anchorage, translation, value creation or empowerment. According to Naber et al. [20], little is known about how experiments scale up and which processes are important for the upscaling of experiments. A few exceptions exist [21,22]. As a response to this lack, Naber et al. [20] have developed a framework for determining sustainable innovation upscaling, and which we have usefully deployed in our analysis below.

Naber et al. [20] distinguish between four patterns of upscaling: a) Growing: when an experiment continues, and more actors participate in the experiment or market demand increases and the experiment grows in size or activity. b) Replication: when the main concept of an experiment is used in other locations. c) Accumulation: when an experiment gets linked to other experiments. d) Transformation: when the experiment shapes wider institutional change in the regime selection environment.

Our prime interest here is the reconfiguration and transforming properties of the smart grid demo projects and experiments. Hence, we are particularly interested in the relationship between the projects at hand and wider institutional configurations. This may give insights on how experiments contribute to shaping the sectors that they are part of and potentially in the longer run instigate institutional change in regime selection environments [14] in line with the transformation analogy proposed by Naber et al. [20].

The literature on strategic niche management have identified three processes particularly important for upscaling: (a) the articulation and the adjustment of expectations and visions; (b) the building of social networks and the enrolment of a growing number of actors; and (c) learning and articulation processes on dimensions such as technical design, user preferences, or symbolic meanings [20]. Schematically, this can be illustrated in the following way, see Figure 1 [23]:

Process	Indicator	Description
Social network building	Broad	The network consists of actors from different domains
	Deep	Resource commitment of the members is high
Articulations of visions and expectations	Clear	Expectations are clearly articulated between members
	Robust	Expectations are shared by the members
	Grounded	Expectations are substantiated by on-going experiments, research and experts
Learning processes	Broad	Learning took place on several dimensions
	Reflexive	Assumptions about underlying problem definitions, function or desirability of solution questioned

Figure 1. Processes important for upscaling. Source: [23] adapted from Naber et al [20].

In the next section, we will analyse experiments considering this conceptualization of upscaling processes. Naber et al. [20] has highlighted that learning processes are particularly important for achieving upscaling of the transformation variant. Thus, in the following we describe social learning processes that lead to patterns of upscaling. Applying the framework of Naber et al. [20], we focus on two cases with a large potential for successfully driving change and which give greater understanding of how reconfiguration unfolds in different domains such as mobility and housing.

3. Methods

For this study, we mobilized a comparative, qualitative case study design. A multiple case study design increases generalizability, as it allows comparison of analytic conclusions across a range of contexts. From the nine cases studied within the ERA-Net project mentioned above, two experiments were selected for in depth analysis herein. This was a decision based on a measure of comparability, as the cases—the Austrian VLOTTE and the Norwegian ASKO—both were smart grid experiments with certain similar features which made them interesting for comparison. Both cases were company driven projects with a focus on the development of solutions to convert vehicle fleets to renewable energy sources. In both cases, the activities were in-house developments aiming first at the companies' own needs. However, at the same time, both activities can be characterized as mission-oriented innovation, as they aimed to contribute to a decarbonized transport sector in general. In the VLOTTE project, a regional Austrian ESCO together with an associated DSO developed a smart e-car park as part of their own e-vehicle fleet. In the ASKO case, a large grocery wholesaler from Norway established a hydrogen infrastructure for a hydrogen-powered fleet of heavy-duty delivery trucks and fork lifts. In addition to a similar thematic mission of the projects, there is another interesting common feature: In both cases, we are dealing with companies that have transformed their relation to and participation in the transport system as an outcome of the project.

Our analysis of the case studies provided a comprehensive description of the activities, framework conditions and outcomes. The empirical surveys therefore focused on the historical development of the projects, the local and regional contexts, and the roles and strategies of various actors. In addition, the solutions developed in the projects were described as socio-technical configurations. Further on, SNM concepts were used to direct the analysis: comparing data to concepts introduced in the theory section. This created an idea of what features and aspects to look for when analysing upscaling dynamics, in line with the transformation category proposed by Naber et al. [20].

Data collection took place between November 2016 and May 2017. Data about the experiments was collected through semi-structured interviews with project partners and analysis of project documents (e.g., evaluation reports project plans, project presentations, and factsheets). Overall, 31 interviews have been conducted altogether in Austria, with a total of 11 interviews related to the VLOTTE case, studied here. In Norway, the total number on interviews was 38, of which 6 were expert interviews conducted with middle and upper management at ASKO. These interviews lasted between one and two hours. All interviews were transcribed verbatim. For each case an individual case description and analysis was written. After the individual reports, the cases were compared with each other and cross-case patterns were identified in an iterative process [24]. Before moving to the analyses of the two cases, in the subsection below we will briefly describe the national context in which the demos are established and embedded.

More Detailed Case Descriptions: ASKO and VLOTTE

The Norwegian case is represented by ASKO midt-Norge, a large grocery wholesaler, and focuses on their endeavour to be self-supplied with energy. At the time of the study, they had installed a 300-m^2 solar PV rig on the roof of their warehouse (storage) complex, the surplus energy of which is going to power a hydrogen production facility. During the next year, they increased the acreage of this PV park to 12,000 m^2. A hydrogen production was planned to fuel delivery trucks that operate in the middle and low north regions of Norway. Most of the solar power, however, was to be used to power the company storage facility to keep goods cold. Because of this, and contrary to most other use scenarios that include solar power, ASKO has a demand curve that follows the production curve of the PV system quite well as the demand for keeping goods cold correlates with the supply of solar energy.

The Austrian case—called VLOTTE—is located in Vorarlberg, the most western region of Austria and focuses on e-mobility, distributed generation and load management. VLOTTE started as a demo project funded by a national e-mobility model region program in 2008. Today, Vorarlberg is one of the leading e-mobility regions in Europe. Led by the local state-owned energy and utility company Illwerke vkw, the VLOTTE project still is the main promoter of e-mobility in the region. After the publicly funded project phase, Illwerke vkw turned VLOTTE into a business model offering several services. One example is consulting on setting up electric vehicle fleets. In our case, a local construction company approached Illwerke vkw with the request to integrate a public charging infrastructure with the company's parking space, which is also the parking space of a shopping centre. In accommodation of this request Illwerke vkw installed a fast charging infrastructure that is owned by them and can be used by customers that own a vkw membership card, but it is also connected to the company's premises and therefore easily accessible by its employees.

In the case of ASKO, the current development is part of a broadly stated mission from the company and company owners to reduce the CO_2-imprint of the grocery sector at large. Additionally, being able to deliver groceries without emitting CO_2 provides a competitive advantage that the company expects to increase in value. The idea to fuel delivery trucks with hydrogen came from a parallel small-scale research project with promising results. Not only may the conversion of excess solar power into hydrogen fuel solve the problem of seasonal PV production fluctuations, but by producing their own emission free fuel ASKO saw themselves as transforming their role, and thus their dependence, in the transport system as well as the grocery sector.

Similarly, in the VLOTTE project the concept for a smart e-car park on the company premises of Illwerke vkw is well embedded in the larger VLOTTE context of building a model region for e-mobility in the whole province. The main challenge in this case was the integration of a large rooftop photovoltaic system and to develop the car park without additional investment in the expansion of the grid connection—a restriction set by the project owner (Illwerke vkw) to provide for realistic framework conditions form the outset.

4. Results

4.1. The ASKO Case

The current regime in which ASKO is operating is the grocery wholesale market in Norway, and the day-to-day operations of the company is to sell and distribute groceries to stores, retailers, and the restaurant and catering industry. To do this, the 13 regional forwarding hubs, of which ASKO Mid-Norway is one, are composed of large, energy intensive cold-storage buildings for storing the goods. ASKO Mid-Norway services around 1700 stores and restaurants in an 800-kilometre radius, and the goods kept within the cold storage buildings are transported by a fleet of around 50 diesel operated distribution trucks. As such, another important regime for ASKO to relate to is the national transport regime. Finally, getting the goods on and off the trucks is facilitated with the aid of forklifts in one end, and in the other, by the lift ramp on the back of the truck itself. In order to operate the lift, the truck needs to idle, thus it consumes diesel and cause large unnecessary emissions to occur, often in urban areas. All these points of energy expenditure, which are representative of how the dominant regime functions, are included in the plan of ASKO to reduce energy consumption, CO_2 emissions, and increase energy self-sufficiency.

ASKO is part of a broader corporate structure with 10 regional branches spread out across Norway. In turn, a large national actor who owns a broad portfolio of corporations such as grocery store and fast food chains owns ASKO. Within this structure, well-defined formal rules and requirements regarding returns on investments has been long established. In other words, companies such as ASKO, have been embedded in a belief and value system where the core desired outcome has been guided by straightforward business economics with the goal of maximizing economic rewards and profit. For the last 7–8 years, however, a key group of owners within this structure, have been working to change the rules of this game. They have become environmental protagonists within ASKO, arguing for the importance of broader societal and environmental engagement in order for the company and the planet to survive. This has resulted in the overarching goals that are now causing the reconfiguration of many of ASKOs core operations. The vision has developed into becoming climate neutral in every aspect of ASKO's operations. This vision became manifest through a decision by the board of directors where it was stressed that the return on environmentally oriented investments could be much lower that than return on "ordinary" investments. Thus, we see that ASKO have visionary owners and directors, with clearly articulated goals. These visions were established in the format of the board meeting but were not only expected to give new guiding principles within the organization. They were also expected to impact other actors in the sector, for whom ASKO wanted to be "ahead of the pack".

It is interesting to note that this top-down push from the ASKO owners was on the one hand, a clearly articulated expectation. On the other hand, it was rather open, in the sense that it did not dictate how companies within the structure should work to become sustainable, only that they should. However, the vision was further translated into concrete goals of being 100% self-supplied with new renewable energy by 2020, as well as switching to 100% renewable fuels for transport.

On a corporate level, the first decision was to invest roughly 20 million euros in a wind park with 60 GHW annual capacity. This would cover the equivalent of 75% of all annual electricity consumption throughout the corporation. Several respondents from the regional branch spoke to how their own initiative was the result of a combination of the external push mentioned above and internal motivation. Thus, we can see how expectations were clearly articulated between members of the organization, and how they, at the same time, spurred local branches to think of their own solutions and to translate the general vision of the company to local needs and interests.

In terms of articulating expectations and visions, ASKO had adopted a robust and vertically integrated approach, to adhere to the terminology of Naber et al. [20]. This included involving the entire workforce, from part-time warehouse workers to regional management, in their vision for ASKO as the most environmentally ambitious corporation in Norway. Articulations of visions may be labelled robust, in the way that they were shared by both top management, regional managers and employees.

We also found the articulations of expectations and visions to be deeply grounded: that is substantiated with ongoing experiments, research and development. As an example, at the time of the interviews, managers did not believe that the hydrogen production facility they were about to start, would be able to deliver as much hydrogen as they thought they would need after 2023. Hence, they targeted other actors more firmly anchored in renewable energy production and tried to enrol them in the future hydrogen fuel cell production. They were for instance, in dialogue with a regional electricity company that had a wind park near the coast which was identified as good fit for producing hydrogen. Winds were just as strong on the coast at night when one does not use much electricity, so producing hydrogen at night could be a way to avoid having to stop the wind turbines. In this sense, ASKO envisioned a future where their ongoing pilot project would be scaled up, and they were actively working to produce market- and framework conditions that would favour such a reality.

The new emphasis on environmental issues on a company level was used to promote what we can call community or individual acceptance of sustainable choices to employees, in other words, a "downward" enactment of transition-oriented agency. This can be interpreted as identity-oriented translation work, which in practical terms meant that the company established employee support mechanisms. An annual environmental fund of roughly 1 million Euro was established, from which employees could get funding for electric bikes, energy efficient home renovations, or tickets to use public transport. On-site, ASKO established electric vehicle chargers, which employees could use for free. Several respondents pointed out how this focus on the material and cognitive aspects of sustainability at the work place gave them a sense of pride and contributed to forming engagement and identity around the company, as a particularly sustainable frontrunner. Thus, ASKO used their own agency and capacity to create new spaces of involvement for their employees. This way they created deeper social networks, demonstrating that resource commitments of the firm and the employees were high.

ASKO was also involved in the building of broader social networks that aligned with their pilot experiment and the enrolment of external actors from other domains to aid them in creating viable socio-technical solutions. This is evident in the efforts made by ASKO Midt-Norge (the local branch) to reduce the idling of trucks in delivery mode using hydrogen. In these efforts, ASKO was initially reluctantly enrolled in a small research project aiming to test and make viable for markets a design for a diesel–hydrogen converter. Through employing this design to keep lift batteries charged and operational during delivery without idling, ASKO managed to reduce emissions from urban deliveries with about 85%. Still a prototype, the design was deemed a success, and the technology is currently part of a project to power mobile refrigeration. However, and most importantly, this collaboration sparked interest in the promise to use hydrogen to decarbonize distribution trucks and dispense with cumbersome necessity of charging batteries in the fleet of forklift trucks. Thus, we see that the social network was broadened, to consist of actors from logistics, research institutes, car manufacturers, electricity companies and, later, as we shall see below, policymakers.

In the case of ASKO, it became evident that the learning process became broad and multi-layered, taking place on several dimensions, impacting the organization through new rules and practices, technical design of the whole delivery operation as well as symbolic meanings related to electricity self-sufficiency and reaching their target of 100% renewable and carbon neutral by 2020. In other words, the experimental environment set up by ASKO still continues, and efforts are now focused on how to make use of hydrogen to fuel delivery trucks, further reducing emissions and fossil fuel consumption.

The regional ASKO manager noted how producing energy entailed a shift in company priorities, understandings and values so that energy and environmental issues became one of the most important things they were doing, in addition the core activity, which was to distribute goods. Their role as being part of a socio-political reality seemed to become more evident to the manager, as well as their capacity to influence and re-shape conditions by influencing the municipalities' procurement rules, giving input to the Norwegian state budget and trying to influence the new national transport plan. Thus, we see typical second-order learnings happening in the ASKO case. We see learning that creates new expectations and create new goals in addition to goal-oriented first order learning and instances where broad networks involving users and outsiders strive to make innovative solutions to become part of market niches.

Furthermore, while ASKO focused on improving environmental performance on the one hand, the corporation is itself heavily involved in the formative processes surrounding national procurement, road and transport policies. As is customary in Norwegian politics, regulatory changes like these are presented to the public with a following hearing period, in which any interested parties may comment on the changes. ASKO used this as opportunities to suggest policies and regulations that would benefit the company and that could leverage environmental capabilities. In this way, expectations and visions were adjusted to accommodate even tougher environmental demands, which in turn would increase the value of environmental assets within a company. Thus, we see the example of a reflexive learning process where assumptions about underlying problem definitions, functions or desirability of solutions are questioned, as evident when ASKO seeks to influence municipality procurement policy to increase the significance of environmental impact of offers.

Other activities clearly aimed to change framework conditions. One example of this is that the ASKO corporation annually provided input to the Norwegian state budget. To this end, they collected input from regional ASKO branches with the goal of providing statements so clear, unambiguous and applicable that they "can just put it straight into the budget". Also, when Norwegian road authorities drafted the new national transport plan a few years ago, ASKO provided an eight-page letter of input, clearly reflecting their environmental ambitions, claiming for instance that the price of renewable fuels, such as bio, electricity and hydrogen should be made competitive with fossil fuels and differentiated through taxes and incentives. This can of course be seen as a general plea for subsidies, but other statements indicate a more direct attempt to enrol the authorities in ASKOs' solar-hydrogen agenda. ASKO considered the responses they received on their ideas to the national budget to be good, but it is difficult to assess their impact on national policy without further studies. ASKO ownership met regularly with politicians from all political parties to improve conditions as the strategy to sit around waiting for those conditions was not perceived effective. Conversely, a frontrunner strategy was expected to configure framework conditions to line up with the capabilities of the company. In this way, ASKO sought protection from public policy measures in line with typical niche protection strategies identified by the literature, while at the same time combining this with a role of regime player, wielding its power to protect its innovation by changing the rules of the game from within (i.e., by putting different demands of return from renewable projects).

In sum, we see that ASKO midt-Norge ventured into becoming one of the region's largest solar power producers. Their endeavour into hydrogen also represents a re-articulation of how to manage intermittent electricity sources and matching production and consumption across infrastructures, sectors and seasons. Furthermore, the case illustrates how the boundaries of the traditional electricity system has increasingly become blurry, and how new networks have been constructed to solve tasks in novel ways. ASKO, as a grocery wholesaler and logistics firm, have not traditionally been part of this system as anything but a very large actor on the "demand side" of the energy system. Now they produced electricity and were venturing into fuel production, while using these assets to leverage disruption in the policy area—for their own benefit—but also for the benefit of a tangible sustainable transition with potential implications for the mobility sector.

Finally, the case illustrates the importance of trust built over time between actors when trying to establish unconventional solutions, showing how new combinations of actors and technologies might open new market opportunities. So far, the pilot project relies on economic support, and it is difficult to predict if framework conditions will change enough to make this economically feasible. However, ASKO has proved that they are prepared to take some losses to facilitate second order learning, reach new long-term gains and fulfil their visions.

4.2. The VLOTTE Case

The VLOTTE project is operated by Illwerke vkw and situated in the region of Vorarlberg in the western-most part of Austria. The project started in 2008 as a nationally funded research and demonstration project. At that time, it was the first e-mobility field test in Austria. Later, after a series of additional research projects carried out by the in-house project team, VLOTTE became its own brand and branch of Illwerke vkw. The project name VLOTTE was chosen at the very beginning and means a new fleet of vehicles (in German 'Flotte') in the Vorarlberg region. The project owner, Illwerke vkw, is a largely (95.5%) regional state-owned enterprise consisting of Vorarlberger Illwerke AG (peak and control energy and tourism), Vorarlberger Kraftwerke AG (energy supply, energy services and energy trading) and Vorarlberger Energienetze GmbH (electricity and gas network). National funding played an important role to stimulate the first activities, but the project also profited from a number of supportive local conditions. Today, Vorarlberg is one of the leading e-mobility regions in Europe.

In 2009, all political parties in the regional parliament agreed on the strategic goal of Vorarlberg becoming energy autonomous by 2050. The energy autonomy goal was understood as a process of development and design of a sustainable energy supply, aimed at fully meeting demand with renewable resources. To reach this goal, the regional government initiated several measures, the program for mobility planning for municipalities being one of them. A participatory vision building process served as the basis for reaching the climate goals after which working groups for the topics renewable energy, buildings, trade and industry as well as mobility and spatial planning were established. These working groups developed frameworks with concrete milestones for each topic. Currently, measures to be taken until 2020 have been agreed on, which is seen as the first stage of the plan to reach energy autonomy in the region by 2050. This process was guided by the European Union's 2020 goals. The 1990 emissions level was taken as the initial point. For Vorarlberg, this means that the energy consumption must be reduced by 15% in comparison to 2005, CO2 emissions by 18% and the share of renewable energy has to be expanded by 13% in comparison to 2009. In this strategy for a climate-neutral Vorarlberg, 101 practical measures were formulated (Energieautonomie Vorarlberg 2011). The start of the VLOTTE project took place in the same period that the comprehensive strategy for Vorarlberg was developed. VLOTTE had started as a project initiated by the e-mobility model region funding program (Modellregionen der Elektromobilität) of the Climate and Energy Fund (Klima- und Energiefonds—KLIEN) and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). E-mobility model regions were not common in Austria at that time, so the Climate and Energy Fund was one of the ground breakers for the establishment of electric mobility.

The general idea behind the e-mobility model region program was to test different e-mobility systems in different regions of Austria and thereby pave the way for e-mobility technology for everyday life. The funding program included three stages: First, to test electric mobility in different regions and building up different systems; second, funding of networking and consolidating projects in cooperation with the different model regions; third, spreading of experiences and gained knowledge in the whole country (Klima- und Energiefonds 2017). The different actions and focal points of the project on vehicles, infrastructure, business and distribution models made it possible to bring around 2000 e-vehicles on the streets and to install about 3000 charging points between 2009 and 2011. The last call of the funding program was in 2014.

At the beginning of the VLOTTE project, in 2008, the development of e-mobility was in a very early phase and there was a very limited amount of charging infrastructure. The proposition for this e-mobility model region was to establish an overall mobility concept for the region and was later included as part of a comprehensive plan for Vorarlberg to become energy self-sufficient by 2050. The main vision of VLOTTE was to establish an e-mobility model region and therefore prove the suitability for daily use of e-vehicles. In the early days, VLOTTE did not have a specific focus, but applied a rather broad approach: new plants for renewable energy were built, charging infrastructure was established and early e-vehicles were brought to Vorarlberg. In this early phase, e-vehicles were not common and mass-produced electric vehicles did not exist. Therefore, experimental e-vehicles and conversion vehicles came into use. The project started with four Th!nk City from the Norwegian company Think Global.

The target group was composed of 40% public administration, 40% businesses and 20% private customers. However, in the beginning, public administration institutions and businesses were the most interested due to the risks and the high costs and perceived as forerunners in the e-mobility innovation process. After the launch of EV models like Mitsubishi i-MiEV private persons were addressed to a greater extent. In 2011, 44% of all new registrations of e-vehicles registered in Austria were within the project VLOTTE (279 e-vehicles). After the publicly funded project phase, Illwerke vkw turned VLOTTE into a business model, which is still operative today. The early business model of VLOTTE was built around a mobility card (Mobilitätskarte), which costs around 500 €/month. It covered the lease of an EV, maintenance costs, a ticket for public transport in Vorarlberg, unlimited access to charging stations and membership in the Austrian automobile club with roadside assistance offered by a large national automobile association. After four years of use, the customers could buy the e-vehicle for 25% of the original price. This was followed up with e-stations where e-vehicles, -scooters and -bikes could be rented. From 2011, it was possible for business and public administration customers to return the car to the leasing company, which cooperated with the VLOTTE project after five years of use. Another important part of the development was establishing an e-mobility centre that, in addition to be a meeting place for vendors, businesses and the public, actively fostered positive attitudes with comprehensive consulting and technical services for e-mobility.

Thus, the VLOTTE project has in fact undergone many iterations moving from being publicly funded into being supported by a viable business model, and the articulation of expectations and visions has been maintained and adjusted accordingly during these different phases. It started out with a broad, but still clear vision to develop an overall mobility concept for the region and prove the suitability for daily use of e-vehicles, later as part of the plan for Vorarlberg to become energy self-sufficient by 2050. Today the vision, representing a marketable e-mobility solution that is affordable and supported by a strong charging infrastructure, is shared by many of the members of the community. Thus, it is both robust and it is deeply grounded, substantiated by ongoing experiments and research projects.

The final stage of VLOTTE has focused heavily on building social networks and the enrolment of a growing number of actors. With the last iteration, business and restaurants have been enrolled to make them able to offer e-parking and charging. While the first phases were focused on disseminating e-mobility through relevant infrastructure upgrades, the latter stages have been business- and user-oriented. A concrete example of this is the transformation of the company's own vehicle fleet. Here, the company aimed to show how a vehicle fleet could be converted step by step to e-mobility using only renewable energy sources with distinct spill-over effects to the local regional community. The project also includes an existing car park and integrates a large on-site rooftop PV system. However, a reinforced grid connection was deliberately omitted in the process—thus, adding a realistic incumbent regime constraint. Instead of a stronger network connection, the problem of charging many electric vehicles at the same time was solved by developing an online-based reservation system and an intelligent load management system.

Another example is where a business owner approached the VLOTTE team requesting that public charging infrastructure to be built at their car park facilities, which incidentally is also the parking space for a nearby shopping centre. Eventually, a fast-charging station was built that is available to use for the company that requested it, but also for any citizen holding an e-mobility card (vkw Mobilitätskarte). This project made use of the knowledge and experience gained from their own fleet project and represents a concrete step towards the dissemination of electric vehicle fleets in the region. Together with the customer and the local network operator, which is closely linked to the VLOTTE project via the common holding company (illwerke vkw), VLOTTE staff developed a cooperation model from which both sides benefit financially. It enables the electric vehicles of the client fleet to be charged quickly. At the same time, the necessary investment costs on the part of the network operator could be kept low.

Thus, we can clearly see that the social networks of the VLOTTE case have been broadened as the pilot have targeted more and more actors from different sectors and that the resource commitment of the operators of VLOTTE is deep to refer to the terminology of Naber et al. [20]. This is related to another dimension that have been very important for the upscaling of the VLOTTE case; the social learning happening in the pilot.

When the Illwerke vkw began to convert its own vehicle fleet to electric vehicles it was configured in such a manner that the cars in the fleet can be easily booked by the employees and at the same time necessary data for the state of charge is collected. Introducing e-mobility in this way constituted a stepwise learning process, which is still ongoing today, but is proving successful in introducing e-mobility on the company level. The learning takes place on several dimensions. In relation to the technical design an automated booking system makes sure the cars are given time to charge, and makes sure the load constraint in the local system is balanced with demand response capability. Thus, the company is also learning how to balance the local grid as part of this solution. This is important since the car park still has a limited grid connection, although in this case it would have been easy to have the network connection strengthened by the participating network operator. To maintain this balance the system can leverage the 60 kW_P rooftop solar PV and two Zebra batteries taken from decommissioned Th!nk electric vehicles. Altogether, this has also added a symbolic component to the learning process, because the company, which had been involved in several eco-related projects, and the employees report that their efforts to green up their transportation has fostered a pride in their workplace. Driving around with their EVs has, according to the employees, had a positive effect by bolstering the good name and reputation of the company.

In sum, the experiment and demonstration activity fostered by the VLOTTE project has proven that load management in the car park works well and helps to charge a larger number EVs without the need to expand local load capacity. EVs are charged when needed and at the same time additional financial investments in network infrastructure were avoided. When it comes to social network building, a significant part of the success of VLOTTE is based on the strong connection between Illwerke vkw and the regional government. As with the ASKO case, political visions directly influence the strategic orientation of the company and vice versa, giving evidence of ambitions to transform at least some features of the existing system. The cooperation with customers and the meeting of customers' demands has been positive, as exemplified in the tailor-made company e-fleet solution. VLOTTE have succeeded in preparing a favourable and well-working environment for e-mobility including charging infrastructure expansion (e.g., it is today the region with the highest number of charging points per capita in Austria), a broad range of consulting services (e.g., tailor-made energy solutions), new business models (e.g., public–private charging station) and products (e.g., virtual electricity storage using existing pumped-hydro facilities). Thus, we see that reflexive learning processes have been an integral part of contributing to the upscaling of the pilot, adjusting the project in accordance with functions, or desirability of solutions along the way.

We also see that the VLOTTE case has been growing as the experiment continues and more actors participate in the pilot, the market demand has increased, and the pilot has grown in both size and activity. In addition, the pilot has been linked to other experiments (such as field tests with stationary batteries in private households) and some of the achievements of the VLOTTE project have been replicated at other locations. Today, Vorarlberg is the region in Austria with the highest penetration of EVs, and the expansion of VLOTTE to Salzburg is also due to the successful implementation of e-mobility in Vorarlberg. Thus, we see that the pilot has been scaled up in several ways: it has grown, become more diversified and comprehensive, accumulated and contributed to transforming the regime selection environment.

5. Discussion: How Experiments, Demonstration Projects and Pilot Projects Can Challenge Existing Regimes

Pilot projects often remain as standalone learning instances where knowledge do not travel far from the demo setting, and where systemic changes do not occur. In this paper we asked to what degree experiments and demo projects function as sites where new system properties, technologies, regulations, business models and user practices are bundled into new configurations and can contribute to transforming the sector and relations between actors in and across different domains of transport and energy systems. In the two cases studied here, we find evidence of properties that produce new alignments between users and technologies that create new expectations about the future energy system. The two pilot projects studied here may be regarded as strategic technological niches according to their abilities to (a) articulate and adjust expectations and visions; (b) build social networks and enrol a growing number of actors; and (c) create learning and articulation processes on dimensions such as technical design, user preferences, or symbolic meanings. The analysis shows that when these processes support the niche experiment, this may empower niche activity and demonstration projects to change, but potentially also grow beyond and transcend the regimes which they are part of.

Looking deeper into what conditions actually support the up-scaling of the pilots studied in this article and make them contributing to the transformation of energy systems and societies, earlier conceptualisations of how to shield path-breaking innovations against mainstream selection pressures gives some clues to which dimensions to consider [14]. For one, we know that "established industry structures form a selection environment through, for example, established network relations, industry platforms, strong user-producer interactions, shared routines and heuristics, existing capabilities and resource allocation procedures. In such situations, path-breaking innovations entering the market might be rejected because they do not fit with existing industry structures and decision-making processes that have emerged in co-evolution with the dominant design" [14] (1026). However, discussed against this backdrop, the cases studied here are configurations that emerge as socio-technical solutions from the outset. In both cases, the focus has been on system innovation and how to bundle elements in a way that may end up as a completely new system solution. Although innovations are developed within quite established industry structures, they are still developed outside of the main industry focus of these companies.

Neither of them provided any low-carbon mobility systems before, and they both entered new domains where they originally were users of technologies and services. Nevertheless, they were capable of finding and defining a niche within these new domains, deploying leverage and cementing a central role within wider societal decision-making processes, shaping these processes in turn to favour their niche assets. Several factors influenced this: their clear visions and expectations that were deeply and broadly supported within the companies due to heavy investment of resources put into social learning within the organization itself, due to broadening the social network and adjusting goals to new visions, preferences and expectations growing out of the pilot and the way they succeeded to enrol actors outside of their core industry. Thus, we find that the actors participate in these experiments based on visions and expectations, which provide legitimacy to invest time and resources in the technology and solutions, even though it does not yet have market value.

Second, we know from earlier work that "in regimes, guiding principles and socio-cognitive processes in the established knowledge base are geared towards incremental knowledge development rather than paradigmatic shifts, and that path-breaking innovations are rejected because insufficient resources are attributed to new knowledge development" [14] (1026). The examples above, however, show how a paradigm shift may be carried through within already established industries such as the Illwerke vkw and ASKO, if on the one hand, articulations of new visions and expectations are clear and robust (shared by both managers and employees, and a growing number of allies in other sectors) and when the network is deep, which means that actors are able to mobilise commitments and resources within the networks. The 'user perspective' is important here, too. Both companies are able to think outside the box, as they never before were in the mobility business (no traditions, no settled practices, no trajectories, etc.). We see that in both cases, the new knowledge development has been secured by developing solutions that are employed first within the organization itself, thus reducing risk and give innovations a better chance of surviving. In these cases, technical adjustments (such as the introduction of solar PV as energy source used for cooling groceries or hydrogen fork lifts) have been made in real world conditions as the pilot has developed, and there has been ample room for social learning, and growing the support of the project internally before exposing it to markets and to other user groups. This underscores the importance of having 'a home market' within the organizations itself as a site for testing, learning and failing before growing the pilot to new sectors, markets and users.

Third, we know from the literature that 'markets and dominant user practices form a selection environment through stabilised market institutions, supply and demand, price mechanisms, user preferences and routines' [14] (1026) and that path-breaking innovations have a hard time entering the market, for example, because external environmental costs are not represented in end-user prices, or because they require inconvenient user practices compared to accustomed habits' [14]. In our cases, these challenges are met by establishing internal and thus heavily protected markets before the technology was taken out of the niche. We find that firm-level initiatives apply these new technologies in market niches, but also target initiatives to directly construct national niches through targeted policy programs (such as in the VLOTTE case, or industry platforms such as the ASKO case).

Fourth, it has been argued that public policies and political power form a selection environment through, for example, prevailing regulations, policy networks and relations with incumbent industries. Political power is exercised to maintain the status quo, in terms of jobs, tax base, and votes, which is a disadvantage for path-breaking innovations, because they require different policies and regulations, and even new political economies [14]. Particularly in the ASKO case, we find that political power is in fact used to change the status quo. The involved actors are highly reflexive when it comes to learning from the project and they have been working hard to enrol politicians and public policies that align with their innovations in order to make conditions more favourable, at the same time as they change the political economies of their sector. In the case of ASKO we see how actors involved in the pilot worked actively to change regulations through giving input to the national transport planning regime on fuels and that they were quite successful in attracting attention from policy networks. This may also be explained by the fact that policymakers face credibility pressures with regard to societal problems, such as sustainability [25], and that they are 'modernist actors' that need, and are therefore often in favour of, experiments and pilots projects because they help them tell stories and make promises about how to solve problems, such as sustainability and CO_2 emissions reductions [4] (139). In the VLOTTE case both sides, politicians and the Illwerke firm influenced each other, and policies probably was a stronger driver, than in the ASKO case. Nonetheless, both cases illustrate that they use their niche activities (and successes) to directly challenge or shape the regimes they are part of in a certain direction.

Previous literature on how to shield path breaking innovations from dominant selection environments has stressed that 'the cultural significance attached to a specific regime form a selection environment through, for example, its widespread symbolic representation and appreciation. Path-breaking innovations are put at a disadvantage, because they represent different cultural values and lacks widespread stabilised representations' [14] (1027). However, our examples demonstrate the way ASKO and VLOTTE have worked actively to change the symbolic representations, for instance by ASKO's climate fund for reducing emissions, energy use and transforming the practices of employees. By investing in social learning and embedding the visions in the organizational structure, they shape cultural values of employees to also align with the greater goals of the company. In the case of ASKO and VLOTTE the employees were able to feel proud at the same time as they were able to represent their companies as being a front runner in promoting a more sustainable transport and logistics sector. Thus, in our examples we do not find evidence that these large firms (that most often are seen as supporting the incumbent technologies) slow down the development, because of vested interests in incumbent technology, as argued by Naber et al. [20] (343). Instead, we see that in both cases incumbent actors engage in 'unknown terrain' were they may be outsiders.

On a closing note, it is worth highlighting the role that expectations seem to play when market and institutional actors strive to reconfigure existing domains such as transport and mobility. Expectations provide direction to learning processes and contribute to successful development of the innovation when they are robust, which means that they are shared by many actors, and the power of expectations increases when they are shared between people [26], and above all, people across the hierarchy, and across domains along the necessary supply chain, including policymakers. Expectations also contribute to niche development when they are substantiated by tangible results from experiments. When more experiments, research reports, experts, and specialists support the actors' expectations, the quality of the expectation increases [27], [20] (343).

Learning processes are crucial because they enable adjustment of the technology, showing that solutions 'work´ (technically and socially) and only later this (working) also helps to replicate and disseminate solutions and the societal embedding facilitate diffusion. Effective learning processes are not only broad, but deep, multi-layered and reflexive, including both first and second order learning. This means that it is not only directed to the accumulation of data and facts, but also focuses on the alignment between the technical (e.g. technology, infrastructure, and industrial development), and the social (e.g. user context, regulation, societal impact) [28].

The process of replacing old technologies with new ones usually takes a long time because existing incumbent technologies will have benefited from improving in the market over a long period. We also know from the innovation literature that user–producer relations are important for the development of new technologies [29] and that improvements of technologies often happen after they have been introduced in the market where they benefit from feedback from customers or learning-by-doing. Thus, what we find in the pilot projects under study is that the experiments and demos probably contribute to speeding up the market introduction of new technologies, such as the hydrogen fork lift. The quality of learning seems to be particularly important for this; in addition to the formation of stable networks, adequate financial and other resources, as well as strong political visions.

Author Contributions: MR developed the overall structure of the paper. MR, TMS, MO and WT contributed to data collection and methodology, the investigation and the analysis. Writing (original draft preparation), review and editing, was done by MR, MO, TMS and WT. MR, MO, and TMS was responsible for project administration and the funding acquisition.

Funding: This research was done in relation to the MATCH-project (see: https://www.match-project.eu/), funded by the ERA-NET Smart Grids Plus. The content and views expressed in this material are those of the authors and do not necessarily reflect the views or opinion of the ERA-NET SG+ initiative. Any reference given does not necessarily imply the endorsement by ERA-NET SG+.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bulkeley, H.; Castán Broto, V. Government by experiment? Global cities and the governing of climate change. *Trans. Inst. Br. Geogr.* **2013**, *38*, 361–375.
2. Haarstad, H. Where are urban energy transitions governed? Conceptualizing the complex governance arrangements for low-carbon mobility in Europe. *Cities* **2016**, *54*, 4–10.
3. Kemp, R.; Schot, J.; Hoogma, R. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technol. *Anal. Strateg. Manag.* **1998**, *10*, 175–198.
4. Raven, R. Analyzing Emerging Sustainable Energy Niches in Europe: A Strategic Niche Management Perspective. In *Governing the Energy Transition*; Geert Verbong, G., Loorbach, D., Eds.; Routledge: Abingdon-on-Thames, UK, **2012**; pp. 136–162.
5. Manders, T.N.; Wieczorek, A.J.; Verbong, G.P.J. The boundedness of intermediaries in transition contexts: The case of connecting mobility. *Environ. Innov. Soc. Transit.* **2018**, in preparation.
6. Sengers, F.; Wieczorek, A.J.; Raven, R. Experimenting for sustainability transitions: A systematic literature review. *Technol. Forecast. Soc. Chang.* **2019**, *145*, 153–164.
7. Ryghaug, M.; Skjølsvold, T.M. Nurturing a Regime Shift toward Electro-mobility in Norway. In *The Governance of Smart Transportation Systems*; Springer: Cham, Switzerland, 2019; pp. 147–165.
8. Jurgilevich, A.; Birge, T.; Kentala-Lehtonen, J.; Korhonen-Kurki, K.; Pietikäinen, J.; Saikku, L.; Schösler, H. Transition towards circular economy in the food system. *Sustainability* **2016**, *8*, 69.
9. Wieczorek, A.J. Sustainability transitions in developing countries: Major insights and their implications for research and policy. *Environ. Sci. Policy* **2018**, *84*, 204–216.
10. Fleck, J. Configurations: Crystallizing contingency. *Int. J. Hum. Factors Manuf.* **1993**, *3*, 15–36.
11. Peine, A. Understanding the dynamics of technological configurations: A conceptual framework and the case of Smart Homes. *Technol. Forecast. Soc. Chang.* **2009**, *76*, 396–409.
12. Dijk, M.; de Kraker, J.; Hommels, A. Anticipating Constraints on Upscaling from Urban Innovation Experiments. *Sustainability* **2018**, *10*, 2796.
13. Geels, F.W.; Schot, J. Typology of sociotechnical transition pathways. *Res. Policy* **2007**, *36*, 399–417.
14. Smith, A.; Raven, R. What is protective space? Reconsidering niches in transitions to sustainability. *Res. Policy* **2012**, *41*, 1025–1036.
15. Geels, F.; Raven, R. Non-linearity and expectations in niche-development trajectories: Ups and downs in Dutch biogas development (1973–2003). *Technol. Anal. Strateg. Manag.* **2006**, *18*, 375–392.

16. Sørensen, K.H.; Lagesen, V.A.; Hojem, T.S. Articulations of mundane transition work among consulting engineers. *Environ. Innov. Soc. Transit*. **2018**, *28*, 70–78.
17. Schot, J.; Geels, F.W. Strategic niche management and sustainable innovation journeys: Theory, findings, research agenda, and policy. *Technol. Anal. Strateg. Manag.* **2008**, *20*, 537–554.
18. Geels, F.W. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environ. Innov. Soc. Transit.* **2011**, *1*, 24–40.
19. Van Dijk, M.P. Smart Eco-Cities Are Managing Information Flows in an Integrated Way: The Example of Water, Electricity and Solid Waste. In *Smart Futures, Challenges of Urbanisation, and Social Sustainability*; Springer: Cham, Switzerland, 2018; pp. 149–168.
20. Naber, R.; Raven, R.; Kouw, M.; Dassen, T. Scaling up sustainable energy innovations. *Energy Policy* **2017**, *110*, 342–354.
21. Jolly, S.; Raven, R.; Romijn, H. Upscaling of business model experiments in off-grid PV solar energy in India. *Sustain. Sci.* **2012**, *7*, 199–212.
22. Seyfang, G.; Longhurst, N. What influences the diffusion of grassroots innovations for sustainability? Investigating community currency niches. *Technol. Anal. Strateg. Manag.* **2016**, *28*, 1–23.
23. Raven, R.P.; Cheshmehzangi, A.; Jong, M.; Sengers, F.; Späth, P.; Xie, L. An institutional perspective on smart city experimentation: Comparing institutional arrangements in Amsterdam, Hamburg, Ningbo and Songdo. Utrecht University Depository. URL: https://dspace.library.uu.nl/handle/1874/351033
24. Yin, R.K. *Case Study Research: Design and Methods*, 3rd ed.; Sage: Thousand Oaks, CA, USA, 2003.
25. Verbong, G.; Geels, F.W.; Raven, R. Multi-niche analysis of dynamics and policies in Dutch renewable energy innovation journeys (1970–2006): Hype-cycles, closed networks and technology-focused learning. *Technol. Anal. Strateg. Manag.* **2008**, *20*, 555–573.
26. Van Lente, H. Promising Technology. The Dynamics of Expectations in Technological Developments. Ph.D. Thesis, University of Twente, Delft, The Netherlands, 1993.
27. Hoogma, R.; Kemp, R.; Schot, J.; Truffer, B. *Experimenting for Sustainable Transport: The Approach of Strategic Niche Management*; Spon Press: London, UK, 2002.
28. Van der Laak, W.W.; Raven, R.P.; Verbong, G.P. Strategic niche management for biofuels: Analysing past experiments for developing new biofuel policies. *Energy Policy* **2007**, *35*, 3213–3225.
29. Lundvall, B.Å. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*; Pinter: London, UK, 1992.