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Photovoltaic diffusion from the bottom-up: Analytical investigation of critical factors

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HIGHLIGHTS

- Integrated SWOT–AHP analysis on bottom-up initiatives for photovoltaic diffusion.
- Quantification of weighting factors based on expert judgments.
- Financial attractiveness and environmental aspects as key success factors.
- Interaction of social innovations with top-down policies.

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ABSTRACT

The objective of this paper is to systematically identify and assess critical factors, which foster or hinder the development of bottom-up initiatives in the diffusion of photovoltaics. Bottom-up initiatives are social innovations, which entail civil engagement in energy transition at a local or regional level, and are expected to play a growing role in the governance of local energy systems in Europe. A mixed design methodology is used to identify critical factors and assess their importance. This involves combining an analysis of strengths, weaknesses, opportunities and threats with an analytic hierarchy process. The findings indicate that successful initiatives are those which are able to draw upon substantial local public interest and trust in the new technology, and which manage to combine financial attractiveness with environmental concerns. The results make clear that the political context is also an extremely important success factor. Given the appropriate circumstances, such initiatives may make a significant contribution in the transition to a sustainable energy system, and thus prove useful in reaching European energy targets.

1. Introduction

Technological innovation has often been seen as the main issue of concern when attempting to increase the amount of renewable electricity generation. To date, the majority of innovation studies have focused on market-based, technological innovation, largely designed with a view to raising competitiveness, rather than the generation of novel social innovations [1]. Over the last few years, there has been a growing interest in innovation that is less technical or top-down in nature, but which instead emerges from the bottom-up [2]. Such developments are often characterized as ‘social innovations’. For example, energy cooperatives and local ownership of renewable energy technologies are attracting increasing attention as social innovations capable of supporting the growing transition toward sustainable energy. Such a societal transition in energy systems may also lead to specific social transformations in those communities and neighborhoods affected [3]. With respect to the substantive distinction that may be made between social and technical innovations, Howaldt and Schwarz [4] state that ‘social innovations do not occur in the medium of technical artefacts but at the level of social practice’. Hence, social innovations are effectively ‘acts of change’ [5] and entail new societal practices, changes of attitude and, in particular, new forms of organization.

Bottom-up initiatives (BUIs) are one example of relevant social innovation. These comprise social movements and other forms of civil engagement in energy transition at a local or regional level. In fact, several communities and regions have formulated explicit policy goals as part of their wish to transform their community by establishing a self-sufficient energy system [6,7]. Bottom-up initiatives may adopt a great variety of organizational forms. For

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example, they may be voluntary associations, social enterprises, co-operatives, or informal community groups, etc. In Austria, different forms of photovoltaic-related BUIs have also been observed in recent years; e.g. farmers who form societies to collectively install and operate photovoltaics (PV) on their roofs [8], or municipalities which use roofs of public buildings for PV plants [9]. Some of these cases require that participants in BUIs themselves provide space for the plants. This automatically excludes those who wish to contribute, but lack suitable roofs or land. Other types of BUIs merely depend on some form of financial contribution. Considering the large diversity of possibilities available, and the relatively broad scope for public involvement, such BUIs can actually be important drivers in the diffusion of new and more efficient technologies [10].

The diffusion of new and more efficient technologies, and thus the increased usage of renewable energy sources, has also been one of the main issues of concern within the energy policy of the European Union. For example, in accordance with [11], renewable energy sources are to be promoted in the internal electricity market. All national member states have thus been required to commit to specific targets for renewable energy production, consistent with the European Commission's overall target of 20% of electricity produced from renewable energy sources by 2020. Other countries such as the USA and Japan have similar objectives. The national target for Austria was set at a share of 34% of energy generated from renewable sources in gross final energy consumption. Looking at the present situation in Austria, we see that this share was already 32.1% in 2012 but that growth has tended to slow down in more recent years [12]. This implies that Austria needs to maintain its effort if it is still to attain the national target of 34% by 2020. In view of the above mentioned energy targets, photovoltaic technology is believed (for several reasons) to be a promising approach in raising the amount of energy produced with renewables [13,14]. Should present global trends in PV expansion continue – PV is now enjoying a growth rate of 35–40% and is the fastest growing renewable energy source worldwide, and module prices continue to fall – the need for current subsidies is likely to disappear in the near future. The fact that small PV plants are not much less cost efficient than large ones (low economies of scale) provides an additional advantage in the spread of this technology. Growth potentials of alternative low-carbon energies often are limited by e.g. the non-availability of rivers for hydro power plants, scarcity of biomass or public resistance to wind parks and nuclear power plants. In Austria, PV technology plays a crucial role in the transition toward a sustainable energy system. Although electricity generation from photovoltaics in Austria makes up only a small percentage of total capacity, experts continue to view the growth potential of PV as being rather bright [15,16]. While in Austria the economic feasibility is still to a certain degree dependent on the prevailing funding scheme (feed-in tariffs for plants >5 kWp), the attractiveness of the technology continues to rise as PV electricity generation costs fall [17,18]. For plants >5 kWp the Austrian Eco Electricity Act ('Ökostromgesetz') guarantees feed-in tariffs (around 13 euro cents/kWp in 2014) for 13 years. This financial support helps community-based PV plants to break even after around 10–12 years. Also, with respect to photovoltaic technology, Maruyama et al. [19] argue that citizens play a significant role in the introduction of PV systems. The technology is not merely a question of introducing new equipment. It also frequently entails changes in environmental awareness, behavior and attitudes [20].

The origins of citizen power plants are mainly rooted in grassroots innovations. Seyfang and Smith [21] describe grassroots innovations as 'networks of activists and organizations generating novel bottom-up solutions for sustainable development'. This includes solutions that respond to the local situation and to the interests and values of the communities involved. They argue that 'in contrast to mainstream business greening, grassroots initiatives operate in civil society arenas and involve committed activists experimenting with social innovations as well as using greener technologies'.

Within the context of social innovations, grassroots innovations are based on innovative niche-based approaches designed to improve the involvement of people at the community level. These initiatives are driven by the idea of developing social structures and the capacity to build resilience at a community level. Moreover, they focus on two key-goals: The first is to satisfy the needs of those people or communities who may in some way be disadvantaged by, or excluded from, the mainstream market economy. In the case of PV, for example, this involves people without suitable roofs for individual PV panel installation and usage. The second goal is to build up ideological commitment so as to develop alternatives to the mainstream hegemonic regime [2].

However, while grassroots innovations are expected to play a growing role in the governance of local energy systems, little is actually known about the impact they have on policy processes and about the diffusion process of the technology [22]. Based on earlier debate, this paper argues that the mainstream perspective of innovations outlined above fails to acknowledge the contribution of social innovations, which can in fact be significant. Our study thus focuses on one type of grassroots innovation as a particular form of social innovation, i.e. bottom-up initiatives for PV diffusion.

The main objective of this paper is to systematically identify and assess the critical factors, which foster or hinder the development of BUIs for PV diffusion in Austria. Of special interest is, how such BUIs characterize their internal key elements, and how they interact with elements in the external environment, such as the existing (top-down) energy policies or market structures.

To address these questions, we identified crucial factors by means of a mixed method design, and quantitatively weighted them using the hybrid method of a SWOT analysis (strengths, weaknesses, opportunities and threats) and an analytic hierarchy process (AHP). To our knowledge, such an approach has not yet been taken. We thus believe this to be the first study to apply an integrated SWOT–AHP analysis to the context of social innovations. This approach provides us with a more holistic view of such a context and shows us how domain-specific professionals evaluate the prospects and challenges of PV bottom-up initiatives.

The remainder of the paper is structured as follows: In the next section, we present our method in detail. In Section 3, we systematically discuss the results of our SWOT–AHP analysis, as well as additional comments provided by participants in our study. In Section 4, we present conclusions from our study and implications for the role BUIs may play in a transformation of the current energy system into a more decentralized system with a higher share of renewables.

2. Method: SWOT and AHP

We apply an integrated SWOT–AHP analysis. This approach was first introduced by Kurttila et al. [23] in order to increase the effectiveness of a primary SWOT analysis as a decision-making tool. Due to the fact that the SWOT represents a mere qualitative analysis, the combination with the AHP makes the comparison of the alternatives more commensurable. This hybrid method has already been successfully applied in the energy sector, for example, in the context of agricultural biogas plants [24], energy management in paper and pulp companies [25], and in the role of photovoltaics in energy transition [16].

In order to apply this hybrid method, we implemented a two-stage study design. In the first stage, we identified potential