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## Looking back at the future: Dynamics of collective expectations about photovoltaic technology in Germany & Spain

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## ABSTRACT

The widespread diffusion of new technologies is often preceded by hypes, that is periods of a strong rise and subsequent fall in collective expectations, which are usually followed by disappointment. In this study, we focused on the multilevel nature of collective technological expectations and analysed the dynamics of expectations about photovoltaic technology in Germany and Spain over the period of 1992–2015 by conducting a media analysis. Our results indicate that a hype and subsequent phase of disappointment with regard to photovoltaic technology occurred in both countries. However, the results also suggest that these, and particularly the phase of disappointment, were associated with different levels of expectations: while the Spanish hype was followed by a period of pessimism with regard to the profitability of the technology, the disappointment in Germany was dominated by the fear that the technology would negatively affect the economy as a whole. Furthermore, the results allow researchers to gain a better understanding of the interactions among technological expectations and policies, and suggest that, in both countries, national policies played a key role in supporting the formation of positive as well as negative expectations.

### 1. Introduction

The implementation of new energy technologies is inherently accompanied by high levels of uncertainty. For instance, technical outcomes are often vague, financial performances are unknown, or societal impacts are unclear (Alkemade and Suurs, 2012; Brown and Michael, 2003). This is particularly challenging for policy makers who are involved in the development of technology policies. Due to restricted resources, only a limited number of new technologies can be selected for support, but since the terms of the actual technological capabilities and the associated societal benefits of eligible technologies are ambiguous, this selection process is difficult (Geels, 2004). In such an uncertain situation, policy makers strongly rely on expectations about specific technologies: the stronger and more credible the expectations about a technology (and its future capabilities) are, the higher the chance for support (Bakker et al., 2012).

In the literature on the sociology of expectations, scholars describe expectations about technologies as collective phenomena that emerge from ongoing social processes and are shaped by multiple actors with various interests (e.g., Bakker and Budde, 2012; Borup et al., 2006; Konrad et al., 2012). In these processes, policy makers seem to play

important dual roles. While they aim to synchronize policy designs with collective expectations to ensure credibility and, more importantly, manage uncertainties (Brown and Beynon-Jones, 2012), they themselves also create and shape expectations by, for instance, announcing government targets or implementing support policies (Hekkert et al., 2007).

Policy makers and associated policy decisions may even trigger the emergence of technological hypes, which have received increasing attention by scholars of the sociology of expectations (e.g., Dedehayir and Steinert, 2016; Ruef and Markard, 2010; van Lente et al., 2013). To gain a more thorough understanding of hypes, Ruef and Markard (2010) and van Lente et al. (2013) distinguished between different levels of expectations and suggested that examining the interplay among dynamics at these levels could provide important insights into the evolution of hypes and their actual impacts on technological trajectories. However, quantitative studies that accurately deconstruct the level-specific dynamics of collective expectations and associated hypes have not yet been conducted.

To our knowledge, this study represents the first quantitative in-depth analysis to explicitly address the multi-level nature of technological expectations and, thereby, allows us to contribute to the sociology

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of expectations. We used solar photovoltaic (PV) technology as our empirical case study and analysed dynamics of associated collective expectations in Germany and Spain, which were among the first countries to effectively support the diffusion of PV technology on a larger scale, but showed very distinct characteristics in terms of diffusion patterns over time, underlying policy processes and associated market structures. To identify expectation dynamics, we conducted a content analysis of articles published by the national newspapers the *Süddeutsche Zeitung* and *El Mundo* over the period of 1992 - 2015.

The structure of this paper is as follows: first, we provide an overview on the sociology of expectations, recap the history of PV policy in Germany and Spain, and describe the research method. We then present the identified dynamics of expectations for each of the two countries. Subsequently, we compare the country-specific dynamics and discuss the relationships among these dynamics and important policy decisions made. As a last point, we conclude and make suggestions for future research.

## 2. Collective expectations in the context of novel technologies

According to the sociology of expectations, the successful development and diffusion of novel technologies strongly depends on people's expectations about their future capabilities. Due to high levels of uncertainties, novel technologies are often evaluated based on their expected capabilities rather than on their actual performance (Borup et al., 2006; Brown and Michael, 2003). In this sense, expectations about technologies provide guidance for those seeking and selecting new technological options (Bergek et al., 2008). By managing uncertainties, technological expectations can be used to mobilize resources, attract actors to the field, and create legitimacy and, thus, actively influence the direction and speed of the innovation process (van Lente et al., 2013). If technological expectations are shared by a large enough number of people (and not only by individual actors or coherent, like-minded groups of actors), they may turn into collectively-held images of the future and become an accepted part of the social repertoire (Konrad, 2006). Particularly such collective expectations may become strongly performative and steer innovative activities in the present (van Lente et al., 2013).

Collectively-held expectations emerge from ongoing social processes in which multiple actors create and communicate various and often contradictory visions and images of the future (Garud and Ahlstrom, 1997). In order to gain attention in a selective environment, innovating actors compete with each other and with incumbents by constantly voicing expectations (Bakker, 2010). Depending on their respective interests, actors communicate optimistic or pessimistic expectations about a technology. Bakker et al. (2011), for instance, metaphorically compared these battles of expectations to an 'arena', which consists of enactors (i.e., technologists) who 'fight' for the attention of potential selectors who, in turn, choose technological options based on their specific needs and the credibility of the expectations raised. In order to successfully communicate expectations, innovative actors often voice expectations that attach moral values to technologies and respond to the underlying values of social actors (Berkhout, 2006). In other words, expectations may turn into moralizing systems that indicate the inferred 'good' or 'bad' aspects of a technology.

The successful communication of positive expectations about novel technologies often triggers technological hypes. Hypes reflect the well observed phenomenon, where the introduction of a technology is accompanied by an initial phase of euphoria with strongly rising expectations about the capabilities of the technology and a subsequent phase of disillusionment with mixed or even negative expectations (Fenn and Raskino, 2008). More precisely, hypes are regarded as

periods during which a strong increase and subsequent decrease in expectations about and societal attention on a technology is observed (Konrad et al., 2012; Ruef and Markard, 2010). Accordingly, hypes also include the visibility of a technology (e.g. through media coverage) or, more precisely, high expectations may constitute a hype only if they come along with high levels of societal attention paid to the technology (van Lente et al., 2013).

Although hypes are per definition followed by phases of falling expectations (and often of disappointment) (Fenn and Raskino, 2008; Konrad et al., 2012; Ruef and Markard, 2010), the sociology of expectations suggests that these be interpreted as periods during which innovations may be promoted rather than interpreted as misleading or deceptive futuristic ideas. Van Lente et al. (2013:1616), for instance, described hypes, or rather the associated expectations, as "explorations of the future that affect activities in the present [...] not as more or less accurate forecasts". Bakker and Budde (2012) went even further and defined hypes as peaks in positive expectations that were not "necessarily and intrinsically inflated". According to this study, enactors successfully share expectations during hypes, but fail to do so during adjacent periods, which increases the chances of competitors and critics to successfully voice negative expectations. This implies that the successful and wide diffusion of technologies depends on the ability of innovation actors to harness the benefits of hypes, but also to avoid or, at least, manage subsequent phases of disappointment.

Technological expectations and associated hype cycles may be closely related to public technology policies. First, public policies may stimulate expectations about technologies or even trigger hypes (Berti and Levidow, 2014; Brown and Beynon-Jones, 2012; Melton et al., 2016). Melton et al. (2016), for instance, showed how the US government created hype-and-disappointment cycles over several decades by formulating unrealistic targets for alternative fuel vehicles. Similarly, Berti and Levidow (2014) uncovered how instrumental national policies had been in fuelling expectations about biofuels in the UK. Moreover, they showed that policy makers even created a lock-in situation during which they had difficulties correcting or adjusting expectations in hindsight, as they ran the risk of losing credibility by frustrating the expectations they had created in the first place. Accordingly, policy makers must take care not to raise expectations, which they cannot adapt later on, in order to avoid credibility losses (Korsnes, 2016; Weber and Rohrer, 2012). Second, public policies may not only create but may also be a consequence of technological expectations. In the 'arena' of expectations described above, policy makers are certainly among the most important selection agents choosing technological options based on the expectations 'offered' by enactors (Bakker et al., 2011).

The characteristics of a technological hype may also strongly depend on the actual level to which associated expectations are linked (Budde et al., 2012; Geels and Raven, 2006). In order to take into account the fact that expectations about technologies may refer to fundamentally different aspects of a technology, Ruef and Markard (2010) and van Lente et al. (2013) have conceptualized the specific, general, and frame levels of expectations (Table 1). Whereas specific expectations refer to individual or localized manifestations of a technology

**Table 1**  
Different levels of expectations.  
(Based on Ruef and Markard, 2010; van Lente et al., 2013).

Level	Description
Specific	Expectations with regard to specific manifestations of a technology
General	Expectations about the technological field as a whole
Frame	Societal hopes and fears that go along with a technology

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