Circular business model experimentation in the solar industry

Nyffenegger, R.[1,2,*]; Baldassarre, B.[3]; Bocken, N.[1,4]; Grösser, S.[2]

[1]Maastricht Sustainability Institute, Maastricht University, Maastricht, Netherlands

[2]School of Engineering and Computer Science, Bern University of Applied Science, Biel, Switzerland

[3]Joint Research Centre of the European Commission, Sevilla, Spain

[4] International Institute for Industrial Environmental Economics (IIIEE), Lund University, Tegnérplatsen 4, Lund, Sweden

*roger.nyffenegger@bfh.ch

Abstract

The imperative for a systematic transition from the unsustainable linear economic model to a circular economy is increasingly pressing. While the photovoltaic (PV) industry is playing a pivotal role in expediting the energy transition through its predominantly linear organization, it simultaneously confronts the emergence of new challenges, notably the proliferation of substantial waste volumes. Consequently, there arises a critical necessity for the development of novel, more sustainable business models (BM) in the context of circular economy. However, effecting the transformation of these business models and their associated ecosystems is a multifaceted endeavour. While experimentation with business models can serve as a catalyst for this process, circular business models (CBMs) often encounter formidable obstacles on their path to market adoption, particularly when necessitating cross-organizational collaboration within ecosystems. This paper adopts a

case study methodology with an action research approach. Collaborating with eight organizations from the Swiss PV industry in the "Swiss PV Circle" project, the authors aim to experiment with CBMs in pilot projects focused on the reuse of PV modules. Initial findings illuminate the technological *feasibility*, encompassing requisite skills and partner networks, as well as the considerable *circularity* potential for prolonging the product lifecycle and niche *desirability* for specific customer segments. However, the *viability* aspect presents a challenge, as prevailing market prices for new PV modules currently render entry into reuse BMs less promising. Subsequent pilot projects seek to explore non-financial value proposition aspects to enhance viability. This paper contributes empirically to the literature on circular strategies within the PV industry and theoretically advances the discourse on CBM experimentation.

Extended abstract

INTRODUCTION

The current linear economic model, with its massive extraction of resources and acceleration of waste, not only causes immense environmental damage, but also harbours risks for companies in connection with fluctuating commodity prices and supply disruptions (EMF, 2014; Ghisellini et al., 2016). Consequently, a shift towards a circular economy (CE) is urgently needed. As an umbrella concept CE envisions an economic shift, decoupling economic growth from resource consumption by intentionally narrowing, slowing, and closing material and energy loops through reduce, reuse, and recycle activities (Bocken et al., 2016; Kirchherr et al., 2023). This transition requires multilevel changes by a set of actors in the social, economic, technical, and cultural sphere (Kaipainen et al., 2023; Konietzko et al., 2020).

One sector of high growth and promise is the solar photovoltaic (PV) industry, as one of the key drivers for renewable energy. Solar energy is currently experiencing a growth spurt (IRENA, 2022; SolarPower Europe, 2022). While this growth is essential for achieving climate goals, it poses new challenges for the solar PV industry (European Environment Agency, 2021). One particularly challenging aspect relates to an increasing stream of end-

of-life PV modules becoming waste (Komoto & Lee, 2018). Projections estimate 250'000 tons of solar PV waste by 2030 and up to 33'000'000 tons by 2050 in Europe alone (Czajkowski et al., 2022). To solve the challenges of such increasing waste volumes and the associated waste of resources and environmental impact of landfill disposal, the solar industry needs to find new, more sustainable economic models (Tsanakas et al., 2020; Van Opstal & Smeets, 2023). Instead of a linear "make-buy-use-dispose" model, where PV modules are sold without an end-of-life strategy, circular strategies such as reduce, reuse, and recycling are becoming more and more prevalent in the PV industry (Komoto & Lee, 2018; Rabaia et al., 2022).

Business model transformations are a complex process, where organizations need to align desirability, feasibility, viability, and circularity considerations, while navigating in "uncharted waters" (i.e., high uncertainty) (Baldassarre et al., 2020; Konietzko et al., 2020). This complexity underscores the necessity for circular business model (CBM) experimentation (Bocken et al., 2021). Literature on the subject is rapidly increasing, with a growing body of approaches, capabilities, tools, and roadmaps (Bocken, Strupeit, et al., 2019; Hofmann & zu Knyphausen-Aufseß, 2022). Nevertheless, CBM still hardly make it to the market (Blomsma et al., 2019; Ritala et al., 2018), while their implementation has been referred by scholars as "a black box" (Baldassarre & Calabretta, 2023; Roome & Louche, 2016). Adding to the complexity is the necessity for cross-organizational collaboration within a circular ecosystem, wherein each firm must ultimately ensure the profitability of its business model amidst a constellation of frequently divergent requirements, divided incentives, and responsibilities (Kaipainen et al., 2023). Literature on this ecosystem aspect of CBM is still limited (Bocken, Boons, et al., 2019; Konietzko et al., 2020).

The goal of this article is to shed light on this complex CBM experimentation process in a particular ecosystem. To this end we pose the following question: *How can experimentation facilitate circular business models in ecosystems?*

METHOD

To address the question, we adopt a case study method using the fast-growing solar industry as a showcase. This method is suitable because it fulfils the three conditions for a case study brought forward by Yin: (1) our research question is asking a "how" question, (2) as researchers we have little control over the events, and (3) the focus is on a contemporary phenomenon (2014, S. 4). Within the case study we use an action research approach. As action research involves a combination of action and reflection in ongoing cycles on real problems in social ecosystems (Coghlan & Brannick, 2005; Shani & Coghlan, 2021), we work together with eight organizations from the Swiss solar industry in the project "Swiss PV Circle" (pv-circle.ch). Besides the Swiss solar association *Swissolar* and the national e-waste collection scheme *SENS eRecycling*, two PV module producer, two PV system installer/owner, and two PV module end-of-live actors, mainly engaging in recycling, are involved. Funding is provided by the *Swiss Federal Agency of Energy*. The project aims to experiment with CBMs in small-scale pilot projects trough continuous and collective learning with the project partners. The focus of this study is on reuse of PV systems, i.e. all activities related to the preparation for reuse, including the collection, transport, storage, cleaning, and simple repair work of PV system components, especially PV modules, which are also quality tested (Tsanakas et al., 2020; van der Heide et al., 2022).

RESULTS

The experimentation endeavors in the first third of the project term show initial findings. From a *feasibility* perspective, the necessary technologies and processes are in place, the necessary skills are available and corresponding partner networks exist. In terms of *desirability*, we identified value propositions that generate superior value for certain customer segments, while having a positive impact on the environment. From a *viability* standpoint, it is imperative to reduce the costs, and consequently the prices, of second-hand PV modules and systems, which are inherently contingent upon market rates for new PV modules and systems. This requires the implementation of scaling and efficiency improvements along the reuse processes, especially in testing and logistics, to ensure long-term profitability. Measures in this regard are currently being evaluated. In terms of

circularity, we see high potential to slow down the resource flow by prolonging the lifetime of PV modules and systems.

In essence, a business model solely focused on financial aspects, which presents used PV systems as a more affordable substitute for new PV systems, without additional value propositions, seems unlikely to provide viable long-term prospects. In the contrary, aspects of the value proposition pertaining to environmental and social dimensions, such as grey energy and carbon footprint considerations or the integration of marginalized employees, present opportunities to extract price premiums within niche customer segments.

CONTRIBUTION

The expected contributions are twofold. First, the study has a practical contribution as it empirically enriches the PV industry literature on circular strategies, specifically reuse. We show collaborative reuse ecosystem patterns that can be leveraged by industry players as well as policymakers towards more circularity. Secondly, the study theoretically contributes to the CBM experimentation research. Building on Konietzko et al. (2020) and Bocken et al. (2019) we advance the debate. Specifically, we (1) provide evidence from a real, in-dept case study of a circular strategy that asserts itself on the market, (2) put forward metrics to measure the impact of CBM, and (3) outline the necessity of an ecosystem approach to build up CBM.

Keywords

solar industry, photovoltaics, circular economy, circular business model, experimentation

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