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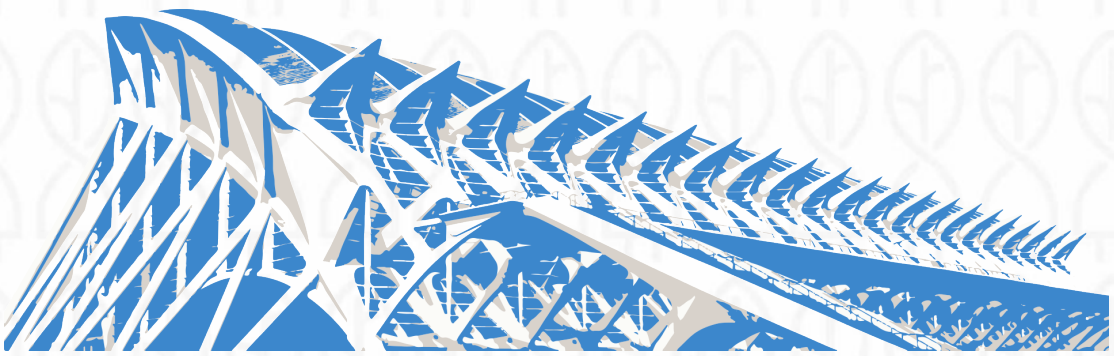

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Collaborative Innovation in Energy: Integrating Design Thinking for Sustainable Product Development

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Abstract

Implementing innovative product development strategies within the energy sector presents unique challenges due to technological complexity, severe regulations, and environmental considerations. Product managers in this industry must navigate a complex web of collaborations across departments to ensure successful.

This paper explores the need to integrate human-centric factors in product development within the energy sector, emphasizing the shift towards collaborative and open approaches. Central to this shift is Design Thinking, which emphasizes iterative and collaborative efforts in driving innovation. The study focuses on the creation of a new line of home solar panels solutions using Design Thinking methodologies. Three workshops - inspiration, ideation, and implementation - are designed and implemented, offering a systematic approach prioritizing user needs, innovative solutions, and iterative refinement. Co-creation workshops engage stakeholders in each stage of the process, facilitating user research, brainstorming, and testing. Results highlight Design Thinking's effectiveness in fostering interdisciplinary collaboration and anticipating implementation challenges. The study underscores the potential of collaborative methods such as Design Thinking in navigating complex challenges and driving successful product development within the energy sector, ultimately contributing to sustainable solutions and organizational success.

Keywords: Sustainable energy; Solar panels; Design thinking; Co-creation Workshop

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1. Introduction

Implementing innovative product development strategies in the energy sector is inherently difficult due to the convergence of technological complexity, rigorous regulatory frameworks, long development cycles and environmental and social concerns (Gmelin & Seuring, 2014). Product managers in the energy industry must navigate an intricate web of collaboration with stakeholders from several departments to ensure the product's success (Hallstedt, Isaksson, & Öhrwall Rönnbäck, 2020). The ability to combine both human and technological factors is critical to product development success and plays an important role in the quality of the final offer that reaches the market (Marion & Fixson, 2021). The need to incorporate technological trends and industry compliance with the environment leads to long cycles of planning generally focused on the technical feasibility or the financial viability of the solutions .

In today's dynamic landscape, the imperative to cultivate sustainable solutions has led to a shift from traditional product development and business model generation towards collaborative and open approaches. The goal is to introduce the product's desirability layer into the process, requiring product managers to spend more time creating empathy with customers before delving into the solution's feasibility and viability components (Shapira, Ketchie, & Nehe, 2017). Central to this shift is the concept of Design Thinking, which emphasizes the iterative and collective effort of a diverse stakeholder group in driving innovation . In this paper, we explore how Design Thinking (DT) methodologies can serve as enablers of co-creation (Prahalad & Ramaswamy, 2004) and open innovation (Enkel, Gassmann, & Chesbrough, 2009), fostering collaboration and accelerating the development of sustainable energy solutions (Hoolohan & Browne, 2020).

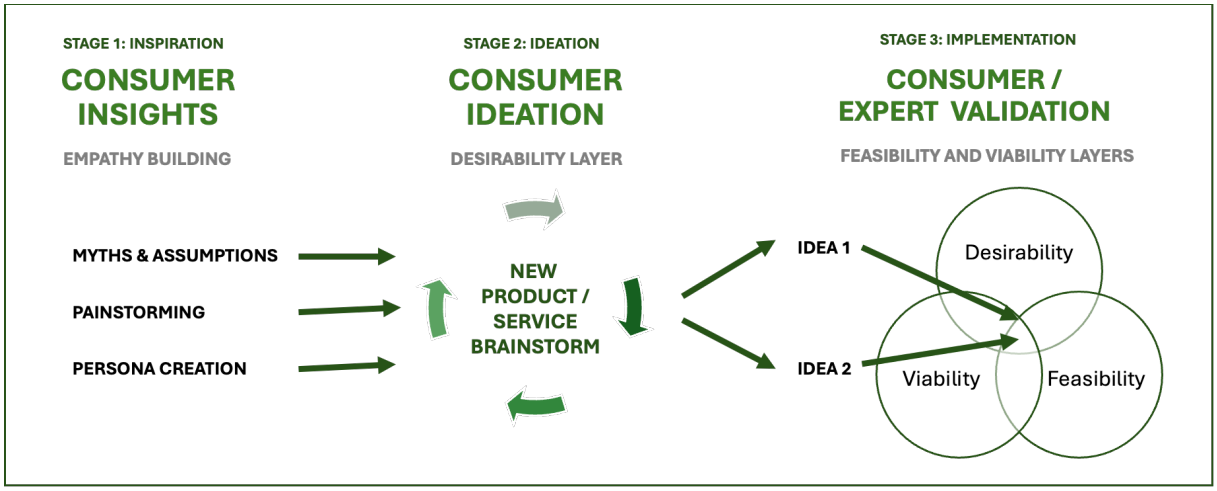
2. Methodology

Our study will focus on the creation of a new line of home solar panels solutions that employed a design thinking methodology (Auernhammer & Roth, 2021) to integrate the marketing and sales teams' vision with the ultimate customer requirement as reflected thanks to collaboration sessions with residential consumers.

2.1 Design Thinking Approach

The approach used for the Design Thinking process consists of three main stages (Brown, 2008): inspiration, ideation, and implementation, each of which is critical for navigating the intricacies of product developement and sustainability (figure 1).

Figure 1. Design Thinking Iterative New Product Design Proccess



Source: adapted from Desirability, Feasibility and Viability Model (IDEO, 2015)

The initial stage, "Inspiration", focuses on immersing oneself in the topic area and getting deep user insights (Liedtka, 2018). This phase focuses on empathy, cultivating a thorough awareness of the user's requirements, emotions, and pain points. By establishing the potential areas for product innovation based on these findings, the framework is established for the next stage: ideation. The "Implementation" stage sees concepts transformed into actual solutions with real-world impact and reflecting about the feasibility and viability constrains before the deployment of the final solution.

To follow the three-stage Design Thinking method we have designed and implemented 3 workshops - inspiration, ideation, and implementation - offering a systematic approach to product development that prioritises understanding user needs, developing innovative solutions, and iterating on those answers through combining users and experts views (table 1).

Table 1. Design Thinking Research Methods

Stage	**INSPIRE**	**IDEATE**	**IMPLEMENT**
Goals	Generate consumer insights on how can we give more customers access to the benefits of Solar Energy by making the offer more attractive?	Thinking with customers about desirable solar energy solutions without considering limitations (technical feasibility or financial viability).	Critically discussing different solutions, defining their value proposition and customer experience from the end user's perspective.
Methods	**Group Discussion** Warm-Up Round What comes to your mind when we talk about solar energy? Myths and Assumptions about Solar Energy Solutions What kind of person uses solar energy?	**Ideation Workshop** 3 Brainstorming Rounds. For each persona the group brainstormed possible product or service solutions that address their specific needs, fears and constraints.	**Group Feedback Discussion** The consumer participant group was complemented with 2 Solar Energy Experts Confront the ideas of the previous sessions to validate the assumptions from the fesibility and viability perspectives.

	Painstorming: What are the reasons for not joining a solar solution? **Personas Generation** We've created 3 types of user personas with different attitudes towards solar energy		Integration of spontaneous (consumer) ideas with expert solutions. Fill out the **Feedback Grid** regaring each idea: "Things that worked," "Needs to change," "New ideas to try," and "Questions we still have"
Number of Participants	13 participants. Written consent to participate in this study was obtained from all residential consumers. Convenience sample based on a heterogeneous group of participants with different profiles (age; energy invoice value; household size; type of house; rented or owned)		

Source: Own elaboration

2.2 Co-Creation Workshop: Inspiration Stage

The first session corresponds to the "Inspiration" stage of Design Thinking, in which the emphasis is on understanding and empathising with the needs and experiences of people (Heylighen & Dong, 2019). This session promotes empathy-building and user research by gathering end-users to discuss their wants, preferences, and pain areas with relation to residential solar panel solutions. Thirteen participants offered their experiences and thoughts, which provided essential information to the brainstorming process. The purpose of prioritising user-centric design principles is to guarantee that suggested solutions answer real-world difficulties and fit with user preferences, making them appropriate for the inspiration stage.

2.3 Co-Creation Workshop: Ideation Stage

The second workshop corresponds to the Ideation stage of Design Thinking, in which the goal is to generate creative solutions to the defined problem (Lee, Ostwald, & Gu, 2020). Participants engage in brainstorming activities while working with marketing experts and industry specialists to analyse the feasibility and viability of suggested solar panel solutions. Participants investigate several solution concepts and assess their technical feasibility, commercial potential, and financial viability using organised activities and scenario analysis. The insights gained from this workshop help to develop solution concepts and aid decision-making on implementation techniques, making it appropriate for the ideation stage.

2.4 Co-Creation Workshop: Implementation Stage

This workshop corresponds to the implementation stage of Design Thinking, which focuses on bringing ideas to life and scaling them for real-world effect (Randhawa, Nikolova, Ahuja, & Schweitzer, 2021). Participants engage in iterative development and testing activities by bringing together end users and marketing experts to negotiate the terms of compromise between desirability, feasibility, and viability dimensions. Stakeholders use guided talks and collaborative decision-making procedures to reconcile opposing viewpoints and establish

mutually acceptable trade-offs. The workshop's goal is to match stakeholder expectations and goals, build agreement, and facilitate the creation of strong, balanced solutions that fulfil the demands of both end users and market players, making it appropriate for the implementation stage.

3. Results and Discussion

Design Thinking allowed for the collaborative exploration of diverse perspectives and ideas by emphasising stakeholder needs and fostering interdisciplinary collaboration. These findings emphasise Design Thinking's potential in producing collaborative creativity and inspire further research into its deployment in a number of contexts.

3.1 Co-creation workshop 1

The first co-creation workshop' purpose was twofold: 1) it had the intent of exploring customers' needs and pain points and 2) co-creating solutions with them. The key outcomes of the first part of the workshop are listed in Table 2, as well as the insights that the product development team derived from them. The discussion around the pain points of acquiring solar panels indicated that solar panels are perceived as products with high effort and low financial attractiveness. Participants mentioned they would need to spend a lot of effort in 1) learning and investigating the details about the product (financial and practical) before deciding to invest, 2) acquiring it, due to the installation, and 3) getting permission for installation in the case they live in an apartment. In financial terms, participants reported a perceived low financial attractiveness, with a high initial investment and long return on investment period. This type of product is also perceived as being only accessible to a certain type of customer with considerable wealth and knowledge about investments and technology.

Table 2 - Outcomes of co-creation workshop 1 and key insights

Reasons for not acquiring solar panels (pain points)	How participants perceive people who have solar panels	Key insights
• Living in an apartment • Installation cost and effort • Initial investment • Durability • Uncertainty about profitability • Long return on investment • Aesthetics • Complexity, doubts • Having to interact with condominium management • Too much work	• Cautious • Knows about investments • Interested in technology • Comfortable financially (being sustainable is expensive) • Greener lifestyle • Over 40 years old • Couple with children • Continuously plan and analyze their life	• Pain points are mostly associated with two key perceived disadvantages of installing solar panels: high effort (to learn about the service and/to acquire it/to get permission to install it) and low financial attractiveness. • Solar energy is perceived as being accessible to a specific type of customer (wealthy, knowledgeable)

Source: Data collected by author

3.2 Co-creation workshop 2

In the second workshop, participants brainstormed ideas that addressed the key pain points discussed previously. The most voted ideas and insights are described in Table 3. The three ideas presented in the workshop included three important elements that addressed the main pain points: 1) virtualization of the panels (invest in solar energy without having the physical panels on the customer's premises), 2) crowdfunding (diluting/sharing the initial investment) and 3) energy as a service (purchasing the solar energy, not the panels).

Table 3 – Most Voted Ideas and Key Insights

Most voted ideas	Key insights from ideas
• Prepaid solar energy card: invest in solar energy and spend your credit on different partners' services • Crowdfunded community solar park: invest on a small solar park to be built on a public lot • Solar garden: Energy company installs solar panels on a building and the energy is sold to the people living in that building	Most desirable ideas are associated with virtualization (invest in solar energy without having solar panels on customer's premises), crowdfunding (diluted/shared investment), energy as a service (purchasing the solar energy, not the panels).

Source: Data collected by author

3.3 Co-creation workshop 3

In the third co-creation workshop, the product development team presented two ideas, Remote Solar Panels and Solar Neighborhood, with the objective of collecting feedback from the participants. In general, both ideas received good feedback and the participants showed interest in the products, which validates their desirability. The inputs and ideas gathered through the feedback grid that directly helped shape the product are described in Table 4. The product development team leveraged this information to derive a list of improvements to be made to the prototype.

Table 4 – Feedback and Impact on Product Design

Idea	Key feedback from participants	Impact on product design
Remote Solar Panels	How does the customer materialize the investment?	Different package options for spending the acquired kWh
	The return on investment is not clear	Improved interface: highlighted benefits
	Is the customer affected by technical problems in the solar park?	Clarified value proposition: customer acquires kWh, not physical panels
	Can the acquired energy be used in more than one house?	Added feature: adding more than one energy contract to the app
	Does the company guarantee the return of the investment?	Clarified value proposition: investment in solar energy, not a financial investment (zero risk of capital loss)
Solar Neighborhood	Benefits for the participants depends on apartment area or energy consumption?	Simplied offer
	Could customers monitor the produced and consumed energy?	Accessible production/consumption data to each member of the community
	Offer based on installation area	Personalized offer based on simulation, drawing the available area for installation on a map
	Can businesses also become producers?	Offer available for B2B market

Source: Data collected by author

4. Conclusion

In this paper we have analyzed a new product development process implemented with a product development team that embeds co-creation in the Design Thinking process, allowing for exploration and testing of ideas with participants (both customers and non-customers). The outcomes from both co-creation workshops support the validity of this approach towards generating and refining products that are innovative and human-centered. The presented case describes how this approach contributed to the development of two new products in the market.

Our findings offer a new understanding of how Design Thinking methodologies might contribute to co-creation and product development in the context of sustainable energy services. Co-creation emerged as an alternative, allowing stakeholders to collaborate and improve solutions to complex problems. Furthermore, Design Thinking accelerates concepts and clarifies future implementation issues, allowing for faster iteration and refinement.

We argue that the proposed approach is adequate for innovating in highly regulated and complex markets, such as the energy market. The Design Thinking approach focused on gathering valuable insights concerning the desirability of the new products (participants are allowed to brainstorm and get creative without knowing in depth all the restrictions in terms of viability and feasibility). The product development team then used this information as a base for their work. Knowing in detail all the feasibility and viability limits (legal, technical, financial, practical), the team refined and developed the ideas internally. In essence, the process is an iteration of internal and co-creation efforts: the team gathers insights through co-creation which then uses to develop the ideas, which then tests and develops through co-creation. The iterative nature of the process allows for a continuous try and fail approach, which is naturally expected in any innovation process.

In conclusion, this experiment illustrates how co-creation and Design Thinking work together to drive sustainable product development. By synthesising findings from 3 collaborative workshops, we help to further the conversation around collaborative innovation in sustainability. Our findings underline the need for comprehensive methods that stress stakeholder participation, interdisciplinary collaboration, and fast iteration. As organisations navigate the intricacies of sustainability concerns, co-creation and Design Thinking provide potential avenues for successful new product development.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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