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Strategic mapping for business model innovation: a pattern-based approach in the electricity industry

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Abstract

Purpose – This paper advances the understanding of business model innovation by proposing a taxonomy of business model patterns and introducing a strategic mapping framework grounded in this taxonomy. We applied this taxonomy to the electricity sector, which is a critical driver of social and global economic development, capturing its unique characteristics, value chain structures and innovation dynamics.

Design/methodology/approach – We took a three-step approach to developing the business model taxonomy, including pattern creation by conducting a literature review, pattern validation using a two-round Delphi card-sorting method and industry specification by allocating each pattern into a specific activity in the industry value chain and by applying the findings to the Three Horizons Framework to map the generated and validated patterns across the horizons.

Findings – We identified and allocated 57 business model patterns into 10 meaningful groups. These findings were applied to the electricity industry, reflecting its ongoing transformation driven by renewable energy adoption, market liberalization, and digitalization. The patterns were categorized into the three innovation horizons. For Horizon 1, patterns such as “Power Plant Optimization” (in upstream segment) focus on optimizing existing business operations. Horizon 2 highlights patterns such as “Market Performance Enhancement” in upstream, “Storage Aggregator” in midstream, and “Small-Scale Energy Storage” in downstream value chain segments that scale new business opportunities. Horizon 3 includes transformative patterns such as “Cooperative Utility” (in downstream segment), which pave the way for future industry disruption.

Originality/value – The taxonomy of business model patterns for the electricity industry developed in this study serves as a book of reference for scholars and managers interested in business modeling ideas and methods. In addition, we show how the identified business model patterns can be integrated with the Three Horizons Framework enabling energy companies to align their short-, medium- and long-term strategic objectives, making this approach uniquely suited to dynamic and rapidly evolving industries like electricity.

Keywords Business model patterns, Business model innovation, Three horizons framework, Electricity industry

Paper type Research article

1. Introduction

The electricity industry is witnessing fundamental changes. Digitalization, an increasing share of renewable energy sources, as well as liberalized markets, open new business opportunities (EU Market Observatory for EU Market Observatory for Energy, 2024; 2025; Li *et al.*, 2024) and thus lead to the emergence of new business models (BRIDGE, 2021, 2023; Ferrigno *et al.*, 2023). To remain competitive in the age of digital transformation, triggered by emerging AI (e.g. AI-driven predictive maintenance for grid infrastructure) (Cavus *et al.*, 2025) and blockchain

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(e.g. decentralized peer-to-peer energy trading) (Galici *et al.*, 2025) applications in the energy sector, firms in the electricity industry need to engage in strategic renewal (Richter, 2012). However, knowing how to develop new and innovative business models can be challenging due to the bounded rationality of managers that results from the speed of change and proliferating possibilities to create value (Song *et al.*, 2024). The use of business model patterns – i.e. a definite configuration of business model elements as proven solutions to recurring problems (Fleisch *et al.*, 2015) – for the creation or rearrangement of business models can address this challenge. In fact, approximately 90% of business model innovation efforts follow pattern-based innovation (Schroedel, 2023) by recombining existing patterns (Lüttgens and Diener, 2016). Therefore, the (re)combination of different patterns can allow firms to improve parts of their business models (Abdelkafi *et al.*, 2013) or to develop entirely new business models (Lüttgens and Diener, 2016). Not least, they allow managers to extend their imagination and discover novel ways of creating and capturing value activities. Also, patterns are useful to reduce complexity and promote communication and a common understanding (Bocken *et al.*, 2014).

Studies on business model patterns have been burgeoning. Researchers have created generic taxonomies (e.g. Gassmann *et al.*, 2014), meta-taxonomies (e.g. Remane *et al.*, 2017), contextual taxonomies, such as for the energy sector (Kubli and Puranik, 2023) or topic-specific taxonomies such as those on sustainability and circular economy (e.g. Abdelkafi *et al.*, 2023; Bitetti and Bedolla, 2024; Evans *et al.*, 2017; Linder and Williander, 2017; Lüdeke-Freund *et al.*, 2018a, 2018b) or those that incorporate sustainability in all dimensions (Schroedel, 2023). These taxonomies are valuable and have gained popularity in practice, education, and academia. Building on the role of patterns in facilitating business model innovation (Velia *et al.*, 2024), we extend business model literature by developing a taxonomy that categorizes patterns into 10 thematic groups, demonstrating how such taxonomies can systematically map emerging business models across different time horizons. While applied here to the electricity industry, the approach advances business model scholarship by showing how pattern-based mapping (Abdelkafi *et al.*, 2013, 2023; Amshoff *et al.*, 2015; Chasin *et al.*, 2020a, b; Falchetta *et al.*, 2022; Remane *et al.*, 2017; Weking *et al.*, 2018, 2020) can reveal value creation and capture mechanisms at a granular level, extend business model typology literature beyond “whole-business” perspectives, and provide a systematic and meaningful method for studying business model innovation trajectories in other sectors. Therefore, this study aims to contribute to the business model literature by taking a strategic mapping perspective for business model patterns to answer the following research question: How can business model pattern taxonomies be strategically mapped to guide the evolution of business model innovations across different time periods?

Based on Lüdeke-Freund *et al.*’s (2018a) multi-method taxonomy (a scheme of classification) building approach, we explore how a business model pattern taxonomy can be built and might be beneficial for the electricity industry. The introduction of renewable technologies, the liberalization of the industry, and novel IoT (Internet of Things) technologies allow for entirely new ways of creating and capturing value in the sector (Pérez-Arriaga and Knittel, 2016). These factors are contributing to changing the way electricity is generated, delivered, and traded (Facchinetti and Sulzer, 2016). Thus, the industry is an ideal setting to map industry-specific business model patterns. Thereby, we can go beyond previous studies that have been consolidating business models (e.g. Burger and Luke, 2017; Richter, 2012) and make our research accessible to the industry. Further, in line with previous research that apply the business model principles to different frameworks (e.g. Foulds *et al.*, 2017), we use the Three Horizons Framework (Curry and Hodgson, 2008) to perform a pattern-based strategic mapping of the identified business model patterns across the electricity sector value chain (actors and activities that add value within the electricity sector chain that introduce and deliver products/services to customers) from upstream (supply and generation of power in power plants and renewable sources that generate electricity) to midstream (transmission of high-voltage electricity to substations and then distribution through lower-voltage networks) to downstream (demand for electricity power at homes, businesses, and industries) (Garlet *et al.*, 2020). Therefore, in Horizon 1, we position core innovations that focus on improving existing business models or processes (short-term focus). In Horizon 2, we focus on emerging innovations that scale new opportunities and introduce more disruptive change (medium-term focus). Finally, in Horizon 3, we identify transformative innovations that explore radically new business models or technologies with long-term impact. Strategic mapping is recognized as a robust and practical tool for identifying and visualizing different themes within a given domain, facilitating the analysis of themes, and uncovering dominant themes and clusters, as well as trends and hotspots within the domain (Thomas *et al.*, 2024).

The structure of the paper is as follows: first, we position business model patterns in the literature on business model innovation and in the electricity industry. Subsequently, we describe the iterative methodology applied to develop the business model patterns. Next, we present the resulting taxonomy and show how it can be applied to the Three Horizons Framework for a pattern-based strategic mapping. We conclude with implications, limitations, and future research directions.

2. Theoretical background

2.1 Business model innovation through business model patterns

Business models explain how value is created for stakeholders and how it is captured by the provider (Massa *et al.*, 2017; Zott *et al.*, 2011). A recurrent and central theme in the business model literature has been the dynamics through which a firm changes its business model to sustain value creation over time. These dynamics can take multiple forms, including business model innovation (the search for new logics and novel ways to create and capture value); business model validation (the assessment of the viability of underlying assumptions before committing significant resources); business model scaling (the rapid expansion of a venture's user base without proportionate increases in resource commitments); and business model pivot (strategic shifts in trajectory that emerge from experimentation and learning to address newly identified problems) (Sanasi, 2023). Although the business model literature has been considered subject to "conceptual ambiguity and disjointed research efforts" (Foss and Saebi, 2017, p. 221), the development of business model patterns as definite configurations of business model elements appears to be an effective approach for achieving convergence and consensus. Particularly in the context of energy management, the concept of business models has become increasingly important in energy efficiency research and development in recent years (Helms *et al.*, 2016; Richter, 2012; Song *et al.*, 2024). With the emergence of digital transformation technologies, new ways of creating, delivering, and capturing value have contributed to the increased interest in business models (Massa and Tucci, 2013). In the energy sector in general and the electricity sector in particular, the introduction of new applications such as digital twins (Li *et al.*, 2024) and the role of data in electricity demand forecasting and optimization (Commin and McClatchey, 2017) have brought significant attention to the role of business models.

While some authors connect business models to strategy and how firms achieve success (Casadesus-Masanell and Ricart, 2010; Massa *et al.*, 2017), others view it as how firms create, deliver, and capture value (Geissdoerfer *et al.*, 2016; Osterwalder and Pigneur, 2010). Thus, the role played by business models has been considered relevant in the whole process of innovation management (Massa and Tucci, 2013). Therefore, business model innovation refers to the process of developing new configurations of business model elements or modifying existing ones to create and capture value in novel ways (Ancillai *et al.*, 2023; Foss and Saebi, 2017). It encompasses a spectrum from incremental improvements to single components to radical transformation of the entire business logic (Grego *et al.*, 2024). Business model innovation can be particularly impactful in industries undergoing structural changes, as it enables organizations to adapt to shifting market dynamics, capitalize on emerging technologies, and respond to evolving customer expectations (Adewumi *et al.*, 2024). In the case of the electricity sector, this is particularly true as suggested by Hall and Roelich (2016), where the authors consider that business model innovation can deliver multiple benefits to the energy system, and has become increasingly critical as traditional utility models face disruption from decentralization, digitalization, and decarbonization trends (Gitelman and Kozhevnikov, 2023; Hamwi and Lizarralde, 2017).

Nevertheless, innovating business models is a challenge for managers (Chesbrough, 2006). Many firms fail in the process of adapting their business models to the changes that are occurring in the market environment. In addition, managers find it difficult to recognize the right business models (Chesbrough, 2006). For example, due to advances in technology, such as the appearance of smart meters and new energy management systems, the electricity industry requires innovative business models because of the complexity of such value propositions (Hall and Roelich, 2016; Song *et al*., 2024). This makes business model development even more challenging. Thus, many firms might need to use other ways and tools to facilitate their business model creativity (Remane *et al*., 2017). According to Song *et al*. (2024), continuous developments in the energy sector, combined with improvements in the policy system, have encouraged more and more businesses to enter the electricity markets with innovative business models that focus on economic, operational, and value-added aspects.

The importance of business modeling tools has been stressed in the literature, as they have been proven useful in terms of group interaction and idea generation during the whole business model innovation process (Eppler *et al*., 2011). In fact, there are multiple tools that could be applied throughout the business model innovation process (the customer value model, the business mapping framework, group decision-support system) (Pynnönen *et al*., 2012). More recently, business model patterns have been popularized as a tool for business model innovation (Bitetti and Bedolla, 2024; Remane *et al*., 2017; Schroedel, 2023). According to Gassmann *et al*. (2014) and Johnson (2010), business model patterns can contribute positively to the interaction within the group and promote creativity through similarities.

To define business model patterns, authors often refer to the work developed by Alexander *et al*. (1977) in the field of architecture. Alexander pointed out that a "*pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it in the same way twice*" (Alexander *et al*., 1977). From this definition, at least three characteristics can be highlighted: first, a pattern describes a problem-solution combination, where the problem is known as important as the potential; second, it is a reoccurring problem (something that already happened before); and third, there is a non-specific and flexible solution to that problem (Lüdeke-Freund *et al*., 2018b). Therefore, a business model pattern is defined as a definite configuration of business model elements as proven solutions to recurring problems (Fleisch *et al*., 2015; Lüdeke-Freund *et al*., 2018b).

The majority of the literature focuses on business model patterns as a list of patterns (e.g. Schroedel, 2023), however, some challenges might be associated with those lists: they are incomplete, they overlap, and they are inconsistent (Remane *et al*., 2017). First, most of the existing lists of patterns found are incomplete because they are not exhaustive. For example, Gassmann *et al.* (2014) developed a list of 55 patterns, while Schroedel (2023) arrived at a list of 92 patterns, and Remane and colleagues (2017) with more than 100 patterns. These patterns are rather generic, which could represent a challenge when a researcher or practitioner is using just one source to find or analyze patterns. Second, they overlap since patterns describe similar ideas, which can lead to redundancies and a lack of robustness (Remane *et al*., 2017). Finally, they are inconsistent as they are not described in a structured way. Some authors developed lists of patterns without any structure, while others present patterns divided into different categories (Timmers, 1998). Consequently, when it comes to their application, especially to a specific industry like the electricity sector, it is rather difficult to apply patterns for business model innovation. Following Weking *et al*. (2018), there are two main reasons that somehow limit the applicability of current business model patterns: (1) they differ in the covered business model elements, and (2) they differ in the level of abstraction, which results in a complex set of business model patterns that are hard to use (Weking *et al*., 2018).

To mitigate these challenges, an efficient way to describe patterns is the so-called "Alexandrian form" (Falconer, 1999; Lüdeke-Freund *et al.*, 2018a), which represents a structured method to describe all the relevant information regarding patterns. Table 1 presents the main aspects that should be considered. This comprehensive format ensures complete and consistent documentation of each business model pattern in our taxonomy.

Therefore, and considering the specificity and complexity of the electricity sector, having all the patterns organized in a structured way will contribute to a better, common, and reliable understanding of the patterns' context, the problem to be solved, and the solution to be applied (Bocken *et al.*, 2014; Lüdeke-Freund *et al.*, 2018a). Also, this structure overcomes one of the main issues regarding previous works on business model patterns, inefficient details, and lack of organizational knowledge. Similarly, building a common language and organizing the knowledge contributes to the creation of a connection between different business model patterns, which might be an advantage for managers during the business model innovation (BMI) process (Remane *et al.*, 2017).

To better understand how different business model patterns compare, and to assess the risks, strengths, and scalability of various models, leveraging existing frameworks is a common and efficient practice (see Schmück *et al.* (2025) as a recent example of mapping Web3 business model patterns). This study, in particular, employs the Three Horizons Framework for a pattern-based strategic mapping of the identified business model patterns across the electricity sector value chain, aiming to foster business model innovation by drawing insights from successful patterns and adapting them to new contexts. This framework is particularly useful for pattern-based strategic mapping in the electricity value chain as a structured approach to managing innovation and change (Curry and Hodgson, 2008). The electricity sector is undergoing rapid change, mainly due to digital transformation and the convergence of end users and supply networks (Maroufkhani *et al.*, 2022). The Three Horizons Framework helps to structure these changes by categorizing business model patterns into three horizons: Horizon 1 focuses on the current state of the business and emphasizes the maintenance and optimization of existing operations and processes, leading to a prioritization of efficiency, cost control, and incremental improvements in the short term. Horizon 2 has a medium-term focus and represents emerging growth opportunities that have the potential to disrupt existing business models. The plan here is to maintain a balance between keeping the current business models and developing new ones. Finally, Horizon 3 is centered on long-term, transformative innovations that could redefine industries or create entirely new markets (Curry and Hodgson, 2008). This framework is a viable and effective tool for strategic planning by balancing short-term efficiency (sustaining and optimizing existing operations; Horizon (1), mid-term innovation (innovating and adapting to new opportunities; Horizon (2), and long-term transformation (envisioning transformative changes and future trends to establish new dominant systems; Horizon (3) (Osei-Amponsah and Abdulai, 2025). Applying the

Table 1. Patterns described in the alexandrian form

Pattern aspect	Pattern description
Name	Name assigned to the pattern
Context	General circumstances that appear to exist when the problem is observed and within which the problem is situated
Problem	The specific problem that needs to be solved, and which this pattern resolves (or attempts to)
Solution	The proposed solution to the given problem
Example	The capture of some known occurrences of this pattern, preferably examples or cultural icons, and show either of its application
Source	Any further reading which may be informative in the subject of this pattern

Source(s): Authors' own work, adapted from Lüdeke-Freund *et al.*, 2018a) framework allowed us to systematically analyze how business model patterns change over time, enriching our recommendations for managers to prepare for and envision future pathways of change, rather than react to them (Osei-Amponsah and Abdulai, 2025). In addition, the framework facilitates the mapping of the electricity ecosystem by specifying how players can sustain profitability (Horizon 1), evolve current innovations into dominant future models (Horizon 2), and invest in future business models (Horizon 3).

2.2 Business model innovation in the electricity industry

The electricity industry is undergoing an unprecedented transformation driven by multiple interconnected forces: sustainability imperatives, technological advancement, and market liberalization (Trahan and Hess, 2021). These forces are fundamentally altering how electricity services are generated, delivered, and traded (Liu *et al.*, 2022; Song *et al.*, 2024). The transition to a more sustainable global electricity system requires not only technological solutions but also innovative business models that can effectively integrate renewable energies and decentralized systems (Barceló *et al.*, 2023; Piterou and Coles, 2021).

Several distinctive types of emerging business models characterize this industry evolution. First, prosumer-centered models have emerged that redefine the traditional consumer role by enabling electricity self-production and grid interaction (Chasin *et al.*, 2020a, b; Botelho *et al.*, 2021; Ertz *et al.*, 2025). These models transform passive consumers into active market participants who can produce, consume, store, and sell electricity (Ableitner *et al.*, 2020; Chasin *et al.*, 2020a, b; Gržanić *et al.*, 2022). Second, platform-based models create multi-sided markets connecting generators, consumers, and service providers in novel ways (Hiteva and Foxon, 2021; Latinovic and Chatterjee, 2024; Shan *et al.*, 2023). These digital platforms facilitate peer-to-peer energy trading and community energy initiatives, often bypassing traditional utility intermediation (Gorbatcheva *et al.*, 2024). Third, energy-as-a-service models shift from commodity-based transactions toward outcome-oriented offerings where providers guarantee specific performance levels rather than simply selling kilowatt-hours (Brown *et al.*, 2022; Karami and Madlener, 2021). Fourth, data-driven business models leverage the proliferation of smart meters. IoT devices and advanced analytics to create value from electricity consumption data, enabling services such as demand response and personalized energy engagement (Aranda *et al.*, 2023; Li *et al.*, 2024; Singh *et al.*, 2021).

Despite these emerging opportunities, electricity companies face significant challenges in business model innovation (Botelho *et al.*, 2022). Traditional utilities, with their asset-heavy infrastructure and established operational processes, often struggle to transition to more agile, service-oriented approaches (Chirumalla, 2021). The extensive regulatory frameworks governing electricity markets further complicate innovation efforts by creating uncertainty around revenue models for new business approaches (Maldet *et al.*, 2022). Moreover, managers typically rely on established knowledge and experience, which can limit their creativity when developing entirely new business models (Bohnsack *et al.*, 2014).

Business model patterns offer a promising approach to navigating this complex innovation landscape by providing tested templates that firms can adapt to their specific contexts. As Song *et al.* (2024) observe, continuous developments in the energy sector, combined with evolving policy frameworks, have encouraged diverse businesses to enter electricity markets with business models focusing on economic, operational, and value-added dimensions. Pattern-based approaches to business model innovation can help companies overcome the cognitive limitations and structural inertia that often constrain innovative thinking within established industry paradigms (Remane *et al.*, 2017). Therefore, we set out to develop a business model pattern taxonomy specifically for the electricity industry, which can guide innovation efforts across different segments of the value chain, from upstream to midstream and downstream.

3. Methodology

Our methodology is based on the multi-method 5-step approach to building business model taxonomies developed by Lüdeke-Freund *et al*. (2018a). Given the focus on industry-specific business model patterns, we adapted the approach in three phases, namely (1) pattern creation, (2) pattern validation, and (3) industry specification (see Figure 1). The methodology progresses from initial pattern identification through literature review (Phase 1), to pattern validation through expert evaluation using a modified Delphi card-sorting method (Phase 2), to industry specification through value chain alignment and the Three Horizons Framework (Phase 3). Each phase builds upon the previous one, resulting in a validated, industry-specific business model pattern taxonomy.

3.1 Phase 1 – pattern creation

In the first phase, we set out to create a list of business model patterns. In doing so we first performed a literature review by using two databases: Science Direct and EBSCO. To find relevant publications, we used three search terms: "*business models AND business model patterns AND electricity*". Sources from both academic literature and practitioner-oriented reports were incorporated into the review. Practitioner reports, also called "*grey literature*", are not peer-reviewed journals (Lawrence *et al*., 2014), yet they are a relevant source of information for new fields of study, which is clearly the case for industries in transformation (Adams *et al*., 2017). These reports were obtained from credible and relevant sources, such as industry organizations, government agencies, and consulting firms known for their expertise in the energy sector. Specifically, we identified the reports by searching the official websites of institutions and centers related to business models in the energy sector. To ensure credibility, we prioritized reports from well-established sources and cross-referenced them with other sources. In total, we compiled a set of 98 articles. Within the compilation set, we identified 247 preliminary patterns. Any identified pattern was directly related to the electricity industry and/or with the emergence of new technologies. Also, the 247 patterns were filtered to eliminate redundancies and non-consistent business model patterns, which resulted in an initial set of 49 patterns. Subsequently, we described each pattern in the Alexandrian form following the five criteria used by Lüdeke-Freund *et al*. (2018a).

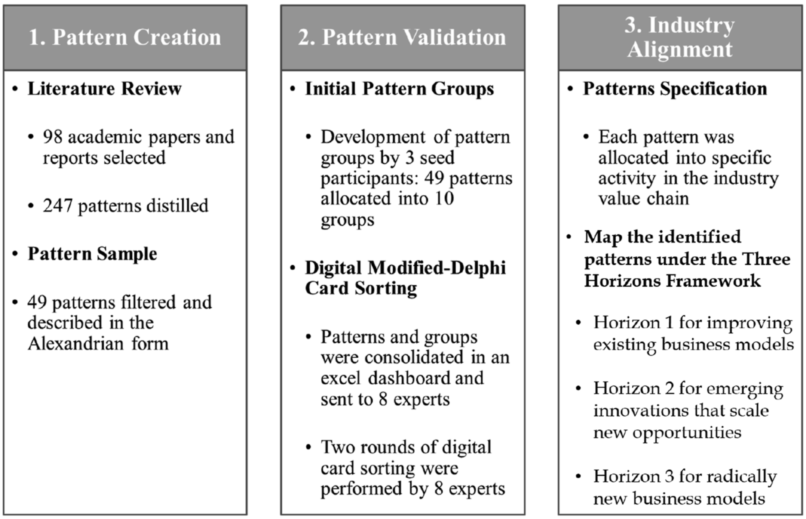

Figure 1. Three phases for industry pattern creation. Source: Authors' own work, adapted from the 5-Step approach by Lüdeke-Freund *et al*., 2018a

3.2 Phase 2 – pattern validation

After the pattern creation, three seed participants allocated the patterns into 10 meaningful groups. A seed participant, who is in charge of developing the initial model from scratch with labeled pattern cards, can be an individual or a focus group. In our case, three individuals were selected to participate: two with an academic background in business models and one with a background in the electricity industry. When it comes to the development of the initial model, some boundary conditions should be considered: each group of patterns should have at least two patterns minimum and ten as a maximum.

Next, we set up a modified Delphi card-sorting process to validate the emerging pattern taxonomy with experts (Paul, 2008). Card sorting is a useful method that allows anonymous participation, yet includes interaction, provides controlled feedback, and includes statistical group response (Dalkey, 1969). Expert interactions involved iterative discussion, review, and refinement by evaluating, adjusting, and categorizing business model patterns through feedback loops to ensure pattern accuracy and consistency. Contrary to previous adoptions of the method (Lüdeke-Freund *et al.*, 2018a), we set up the card sorting as a new digital Excel file, which reduced transaction time, increased convenience, and therefore led to more engaged participation. Our Excel-based approach offered several methodological advantages beyond transaction time reduction. The digital format ensured standardized presentation of pattern information to all experts, eliminated physical card handling constraints (Lüdeke-Freund *et al.*, 2028a), and enabled automated calculation of metrics. To ensure methodological robustness despite this adaptation, we implemented several safeguards, including standardized templates with protected calculation cells, clear instructions with consistent formatting, and version control procedures to maintain data integrity throughout the evaluation process. This digital adaptation preserved the core principles of traditional card sorting (Lüdeke-Freund *et al.*, 2018a) while enhancing participation quality, particularly important for engaging geographically dispersed experts with specialized industry- and region-specific knowledge (Haddad *et al.*, 2020).

To select an unbiased panel of experts, we followed four criteria ensuring sufficient breadth, depth, and objectivity in the data collection process: (1) knowledge and experience in the field, (2) availability to participate, (3) time to perform the exercise, and (4) communication skills (Lüdeke-Freund *et al.*, 2018a). Following these criteria, we selected eight experts based on their backgrounds and experience.

These eight experts represented diverse perspectives within the electricity sector, with balanced representation among academic researchers, utility sector professionals, and energy consultants. Collectively, they brought expertise spanning multiple segments of the electricity value chain and different geographic markets, ensuring comprehensive evaluation of patterns. Table 2 presents a summary of the experts involved in this study.

The modified Delphi Card Sorting was performed in two rounds (see Figure 2). Figure 2 shows the card used by experts to categorize patterns into groups and propose new ones. The two-round approach was specifically chosen to balance thorough pattern evaluation with expert engagement and also follow previous research using the same methodology (Lüdeke-Freund *et al.*, 2018a). In the first round, eight experts from academia and industry participated in a closed card-sorting activity to identify missing patterns, validate groupings, and minimize potential bias through expert feedback. The Pattern Agreement Weight (PAW), which measures the percentage of experts who assigned a particular pattern to a group, was used for consensus. Accordingly, the pattern was assigned to the group with the highest PAW score. For distribution in the first round, each expert received two documents by email: the instructions that contain an introduction to business model theory, as well as relevant information about the method and how it works; and an Excel dashboard with the complete list of patterns, groups, and patterns' descriptions. In this first round, the experts were allowed to create and suggest new patterns and groups, and they were also able to suggest new allocations. If new groups or patterns were suggested, the experts needed to provide a detailed description of each one. In the second round, the rules were slightly different; that is, the experts were only allowed to

Table 2. Experts background

Expert	Background	Country	Years of experience in the sector	Position
Expert 1	Electricity Sector	Romania	10	Strategic Manager
Expert 2	Academic//Electricity Sector	UK	15	Full Professor//Consultant
Expert 3	Electricity Sector	France	9	Innovation Manager
Expert 4	Academic//Electricity Sector	UK	17	Associate Professor//Board Team Member
Expert 5	Electricity Sector	Germany	14	Project Manager//Consultant
Expert 6	Academic	The Netherlands	15	Associate Professor
Expert 7	Academic//Electricity Sector	Cyprus	20	Director
Expert 8	Electricity Sector	Norway	18	Head of Energy Systems

Source(s): Authors' own work

change pattern allocations. To further strengthen methodological rigor, we implemented additional bias mitigation strategies beyond anonymous participation, including an independent evaluation process to prevent groupthink and systematic statistical analysis through pattern agreement weights (PAW) and group agreement weights (GAW) metrics to provide objective measures of consensus. Following Paul (2008), at least 50% of the agreement should be reached.

This structured yet flexible approach is particularly valuable for taxonomies in rapidly evolving sectors where experts' insights may identify emerging patterns not yet documented in the literature.

3.3 Phase 3 – industry alignment

After the second round, the final business model pattern taxonomy was concluded. As aforementioned, a pattern is considered a solution for recurring problems, which means that having an industry-specific business model patterns taxonomy may be useful to solve problems during the BMI process. Additionally, a business model pattern is considered a definite configuration of business model elements as proven solutions to recurring problems. However, this is one of the main issues found in the current list of patterns available in the literature, which are generic and not focused on a specific industry. Therefore, phase 3 was dedicated to allocating the final set of business model patterns along the value chain of the electricity industry, from the generation of power (upstream) to power transmission and distribution (midstream), and demand for electricity power (downstream). Furthermore, the identified and validated patterns were mapped across the Three Horizons Framework to guide strategic decision-making and support short-, mid-, and long-term business model innovations in the electricity sector. This is particularly relevant in our case, as this industry presents some complexities, such as governmental policies, regulations, and/or differences across markets. The allocation of patterns may help managers to innovate business models based on specific parts of the value chain (upstream, midstream, and downstream). It is worth noting that this industry-specific focus ensures practical relevance, given the complexities of governmental policies, regulations, and market variations. However, while the study's business model

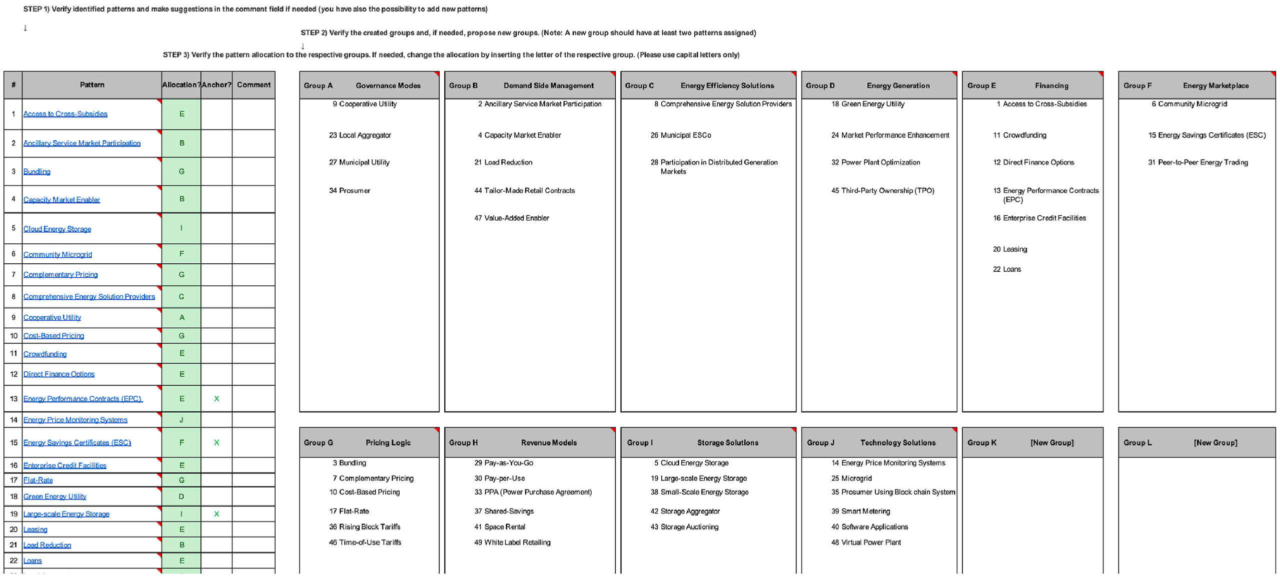

Figure 2. Example of the card shared with experts. Source: Authors' own work

pattern taxonomy is tailored to the electricity sector, the structured approach could be adapted to other energy sectors with necessary contextual adjustments to modify the taxonomy to fit different regions or energy sectors. These adjustments may include regulatory and policy differences in market rules and conditions; value chain structures with different members and interrelationship cooperation mechanisms; technological variations to account for differences in available technologies, infrastructure, and levels of digitalization; market positioning and competitive pressures with different levels of market liberalization, competition, and customer behavior; and economic and environmental factors, including region-specific cost structures and sustainability priorities.

3.4 Supplementary materials

To maintain manuscript conciseness while providing comprehensive details, we have included extensive supplementary materials that complement the main text. These materials contain a detailed description of all 57 business model patterns using the Alexandrian form, which includes six key elements for each pattern: Name, Context, Problem, Solution, Example, and Source. This structured documentation ensures that each pattern is consistently described with both theoretical context and practical applications. For instance, patterns like “Storage Aggregator” (P42) and “Active Customer” (P34) are documented with real-world examples from companies like Limejump in the UK and references to relevant academic literature.

The supplementary materials are organized according to the ten pattern groups identified in our taxonomy (Groups A through J), making it easy for readers to locate patterns related to specific business model themes such as Governance Modes, Demand Side Management, or Technology Enablers. This comprehensive pattern database serves as a valuable reference for both researchers and practitioners seeking to understand and implement specific business model innovations in the electricity sector.

Throughout the manuscript, we reference these supplementary materials to guide readers seeking additional detail. The supplementary materials are available online via the journal’s supplementary content repository, allowing readers to access the complete pattern database while maintaining focus on the conceptual framework and key findings in the main text.

4. Results

In the first round, three seed participants on business model innovation and the electricity sector worked together to create an initial model. After several interactions, the initial set of 49 patterns (see Table 3) was allocated into 10 groups. Each pattern (numbered P1-P49) represents a distinct business solution categorized into ten conceptually related groups. Pattern names indicate the core business approach, with the group descriptions explaining the unifying concept. For example, “Governance Modes” (Group A) contains patterns related to organizational structures, while “Pricing Logic” (Group C) contains patterns describing different pricing approaches. Full Alexandrian-form descriptions of all patterns are available in supplementary materials.

The creation of patterns and groups followed a certain logic, and this logic was mainly based on three different aspects: 1) specific elements of the business model, like value creation (e.g. Group A or G-A and Group E or G-E); 2) based on the value chain of the electricity sector (e.g. G-B and G-D), and 3) focused on efficient electricity processes (e.g. G-C and G-J).

Indubitably, the name of patterns has influenced its allocation. For example, G-I (Group I) “*Energy Storage*” has three patterns assigned with their names ending in “energy storage”. However, these similarities in the pattern names are in accordance with the methodology proposed by Paul (2008). The modified Delphi card sort leads to a more efficient consensus, including in the naming of groups and patterns, than an open card sort does.

Table 3. Initial business model patterns

Pattern groups	Included patterns
Group A–Governance Modes "Different customers, members of an energy-related organization, working together"	*A-09* - Cooperative Utility *A-23* - Local Aggregator *A-27* - Municipal Utility *A-34* - Prosumer
Group B–Demand Side Management "Change in consumption patterns to better match demand with supply"	*B-02* - Ancillary Service Market Participation[a] *B-04* - Capacity Market Enabler *B-21* - Load Reduction *B-44* - Tailor-Made Retail Contracts *B-47* - Value-Added Enabler
Group C–Energy Efficiency Solutions "Reduce the energy required for the provision of services of products"	*C-08* - Comprehensive Energy Solution Providers *C-26* - Municipal ESCo *C-28* - Participation in Distributed Generation Markets
Group D–Energy Generation "Energy activities related to production and consumption"	*D-18* - Green Energy Utility *D-24* - Market Performance Enhancement *D-32* - Power Plant Optimization *D-45* - Third-Party Ownership (TPO)
Group E–Financing "Funding for energy projects"	*E-01* - Access to Cross-Subsidies *E-11* - Crowdfunding *E-12* - Direct Finance Options *E-13* - Energy Performance Contracts (EPC) *E-16* - Enterprise Credit Facilities *E-20* - Leasing *E-22* - Loans
Group F–Energy Marketplace "Energy exchanging activities"	*F-06* - Community Microgrid *F-15* - Energy Savings Certificates (ESC) *F-31* - Peer-to-Peer Energy Trading
Group G–Pricing Logic "How to set the price for the electric product/service"	*G-03* - Bundling *G-07* - Complementary Pricing *G-10* - Cost-Based Pricing *G-17* - Flat-Rate *G-36* - Rising Block Tariffs *G-46* - Time-of-Use Tariffs
Group H–Revenue Models "How to generate revenues from energy projects"	*H-29* - Pay-as-you-go *H-30* - Pay-per-Use *H-33* - PPA (Power Purchase Agreement) *H-37* - Shared-Savings *H-41* - Space Rental *H-49* - White Label Retailing
Group I–Storage Solutions "Energy storage technologies"	*I-05* - Could Energy Storage *I-19* - Large-Scale Energy Storage *I-38* - Small-Scale Energy Storage *I-42* - Storage Aggregator *I-43* - Storage Auctioning
Group J–Technology Solutions "Informational energy systems based on IoT and big data"	*J-14* - Energy Price Monitoring Systems *J-25* - Microgrid *J-35* - Prosumer Using Block Chain Systems *J-39* - Smart Metering *J-40* - Software Applications *J-48* - Virtual Power Plant

Note(s): The pattern names were formatted to be as concise as possible while remaining unique enough to highlight their key aspects, [a]Note that the name of the pattern "*Ancillary Service Market Participation*" (P2) was adapted during the pattern development. The pattern is now called "*Participation in Balancing and Ancillary Service Market*", as some ancillary services are used to balance energy.

Source(s): Authors' own work

4.1 Round 1 card sorting

In the first round, eight experts were asked to conduct a closed card-sorting activity based on the initial model explained above. All experts have different professional backgrounds related to the electricity sector. To reach a convenient balance in terms of knowledge, we selected experts from practice and experts with an academic background. Round 1 is also an opportunity to find new, missed patterns or groups. Moreover, this round is valuable to receive feedback from experts, which can contribute to avoiding potential bias.

To analyze the collected data and see if there is a consensus among experts, two different measures were used. First, the pattern agreement weight (PAW). According to Paul (2008), this measure is calculated by dividing the number of occurrences of a specific pattern in a group by the total number of experts. The PAW ranges from 0% to 100%, where 0% means that no expert allocated the pattern to a group, and 100% means that all experts allocated a pattern to a group. Following this logic (Paul, 2008), PAW is useful to decide in which group a pattern should be assigned. A pattern should be allocated to the group that reached the highest PAW (Lüdeke-Freund *et al*., 2018a, b; Paul, 2008).

$$PAW = \frac{number\ of\ pattern_{(name)}\ in\ group}{number\ of\ experts} x100$$

Formula 1. Pattern agreement weight calculation.

The second measure is related to the group agreement weight (GAW). The GAW defines the agreement of experts on the composition of groups. It is calculated by dividing the total number of patterns assigned to a specific group by the total number of experts and the number of unique patterns assigned to a specific group (see formula 2). As well as with PAW, GAW ranges from 0% to 100%, where 100% means that all experts assigned the same patterns to the respective group (Lüdeke-Freund *et al*., 2018a; Spencer, 2009).

$$GAW = \frac{number\ of\ all\ pattern\ cards\ in\ group}{number\ of\ experts\ x\ number\ of\ unique\ patterns\ in\ group} x\,100$$

Formula 2. Group agreement weight calculation.

According to Paul (2008), it is not mandatory to reach a 100% agreement. Lüdeke-Freund *et al*. (2018a), suggests that patterns and groups should reach a consensus of at least 50%.

From the initial model, the average PAW was around 95%, indicating a high level of agreement among experts. As shown in Table 4, thirty-two patterns reached a PAW of 100%, resulting in full consensus among all experts when it comes to allocating these patterns to groups. Fourteen patterns reached a PAW of 87.5%, which means that at least one expert assigned these patterns to a different group than proposed in the initial model, for instance, P18 was initially assigned to G-D, and one expert assigned it to G-L; or P23 was assigned to G-A and one expert moved that pattern to G-D. Three patterns (P28, P24, and P45) reached a PAW value of 75%, meaning that two experts assigned those patterns to different groups. Considering that all patterns have reached a PAW of at least 75%, no changes in patterns' allocation were needed.

The GAW value per group is shown in Table 5. The GAW average was 71.1%, and values range from 42.9% to 87.5%. These percentages mean that at least one group did not reach a consensus between experts (G-F "*Energy Marketplace*"). The main reason for this is that four experts suggest eight new patterns. All the remaining groups have reached a consensus among experts. The G-E "*(Project) Financing*" reached 87.5% of an agreement, which represents the highest percentage.

Considering the feedback from all experts, specific changes were made: (1) one group was renamed (G-J) previously called "*Technology Solutions*" was then named "*Technology*

Table 4. Paw percentages after Round 1

Pattern groups	Included patterns	PAW
Group A–Governance Modes	*A-09* - Cooperative Utility	100%
	A-23 - Local Aggregator	88%
	A-27 - Municipal Utility	100%
	A-34 – Active Customer	100%
Group B–Demand Side Management	*B-02* - Ancillary Service Market Participation	88%
	B-04 - Capacity Market Enabler	100%
	B-21 - Load Reduction	100%
	B-44 - Tailor-Made Retail Contracts	88%
	B-47 - Value-Added Enabler	100%
	B-54 - Energy data as a service (DaaS)	
Group C–Energy Efficiency Solutions	*C-08* - Comprehensive Energy Solution Providers	88%
	C-26 - Municipal ESCo	88%
	C-28 - Participation in Distributed Generation Markets	75%
Group D–Energy Generation	*D-18* - Green Energy Utility	88%
	D-24 - Market Performance Enhancement	75%
	D-32 - Power Plant Optimization	100%
	D-45 - Third-Party Ownership (TPO)	75%
Group E–Financing	*E-01 - Access to Cross-Subsidies*	*100%*
	E-11 - Crowdfunding	*100%*
	E-12 - Direct Finance Options	*100%*
	E-13 - Energy Performance Contracts (EPC)	*100%*
	E-16 - Enterprise Credit Facilities	*100%*
	E-20 - Leasing	*88%*
	E-22 - Loans	*100%*
Group F–Energy Marketplace	*F-06 - Community Microgrid*	*88%*
	F-15 - Energy Savings Certificates (ESC)	*100%*
	F-31 - Peer-to-Peer Energy Trading	*100%*
	F-51 – Local Market Operator	
	F-55 - Collective self-consumption	
	F-56 - Wholesale Market participation	
Group G–Pricing Logic	*G-03 - Bundling*	*88%*
	G-07 - Complementary Pricing	*100%*
	G-10 - Cost-Based Pricing	*100%*
	G-17 - Flat-Rate	*100%*
	G-36 - Rising Block Tariffs	*100%*
	G-46 - Time-of-Use Tariffs	*100%*
	G-57 - Power-based tariffs	
Group H–Revenue Models	*H-29 - Pay-as-you-go*	*100%*
	H-30 - Pay-per-Use	*100%*
	H-33 - PPA (Power Purchase Agreement)	*100%*
	H-37 - Shared-Savings	*100%*
	H-41 - Space Rental	*88%*
	H-49 - White Label Retailing	*100%*
Group I–Storage Solutions	*I-05 - Could Energy Storage*	*100%*
	I-19 - Large-Scale Energy Storage	*88%*
	I-38 - Small-Scale Energy Storage	*88%*
	I-42 - Storage Aggregator	*100%*
	I-43 - Storage Auctioning	*100%*
	I-52 - Using cars to store and transport energy P2P	

(*continued*)

Table 4. Continued

Pattern groups	Included patterns	PAW
Group J–Technology Enabler	*J-14 - Energy Price Monitoring Systems*	*100%*
	J-25 - Microgrid	*100%*
	J-35 – Blockchain System Applications	*100%*
	J-39 - Smart Metering	*88%*
	J-40 - Software Applications	*100%*
	J-48 - Virtual Power Plant	*88%*
	J-50 – Charging System Operator	
	J-53 - Energy infrastructure/platform as a service (IaaS/ PaaS)	

Note(s): Patterns marked in italic without corresponding PAW values represent new patterns suggested by the expert panel during Round 1 of the evaluation process
Source(s): Authors' own work

Table 5. GAW percentages for Round 1

Group ID	Group name	GAW
G - A	Governance Modes	80%
G - B	Demand Side Management	62.5%
G - C	Energy Efficiency Solutions	65.6%
G - D	Energy Generation	60.4%
G - E	Financing	87.5%
G - F	Energy Marketplace	42.8%
G - G	Pricing Logic	75%
G - H	Revenue Models	85.7%
G - I	Storage Solutions	79.2%
G – J	*Technology Enabler*	71.9%

Source(s): Authors' own work

Enabler". One of the experts highlight the fact that technology solutions could be too generic, considering the patterns allocated to the group; (2) eight new patterns were suggested, assigned to a group and described in the Alexandrian form; (3) considering the suggestion from one expert, two patterns were renamed P34, initially called "*Prosumer*" was then called "*Active Customer*" to be in line with the updated "Electricity Directive [1]", and P35 called "*Prosumer Using Block Chain System*" was renamed to "*Block Chain System Applications*"; (3) based on the comments from experts, some descriptions of patterns were reformulated.

To sum up, Tables 4 and 5 demonstrate the level of expert consensus achieved during the first round of the Delphi card-sorting exercise. Table 4 shows the PAW for each pattern, which measures the percentage of experts who allocated that pattern to the same group. The high PAW values (ranging from 75% to 100% with an average of 85%) indicate strong initial agreement among experts on pattern allocation. Notably, thirty-two patterns reached the full consensus (100% PAW), while only three patterns showed moderate disagreement with a PAW of 75%. This initial string agreement validates the preliminary structure of our patterns taxonomy. Table 5 presents the GAW for each group, measuring the overall consensus on group composition. The average GAW of 71.1% demonstrates a moderate strong agreement on the collective composition of groups, with values ranging from 42.9% for Group F to 87.5% for Group E. The lower GAW for Group F primarily resulted from expert suggestions of new patterns that were not in the initial model, indicating that this area of the taxonomy required expansion rather than restructuring. These metrics provide quantitative validation of our pattern taxonomy structure while highlighting specific areas for refinement in the second round.

After the integration of all changes, the Excel file was re-submitted to the eight experts to conclude the second round which is described in the next subsection.

4.2 Round 2 card sorting

The second round of this exercise follows the same logic as round one; the only difference is that experts were no longer allowed to suggest new patterns and new groups. Thus, the main purpose of this round was to review and improve the initial model in terms of patterns, group naming, or allocation.

Analyzing the PAW and GAW (see Tables 6 and 7) a consensus was reached. In terms of PAW, the average increased from 95% to 96%, and the GAW average from 71.1% to 80.2%. Compared to the first round, forty-one patterns reached the 100% consensus in the second round.

Concerning GAW, one group reached the 100% agreement “G-G *Pricing Logic*” meaning that all experts agreed with the patterns allocated to that group. However, “G-C *Energy Efficiency Solutions*” decreased its GAW from 65.6% to 45.8%. This was due to some changes in the allocation patterns to this group in the second round.

In a nutshell, Tables 6 and 7 illustrate the improvements in expert consensus achieved in the second round after incorporating feedback from round 1. Table 6 shows the revised PAW values, with the average increasing from 95% to 96%. The number of patterns reaching full consensus increased from thirty-two to forty-one, indicating that the refinements made after round 1 successfully addressed areas of initial disagreement. This progressive convergence of expert perspectives confirms the validity of our pattern allocations and the effectiveness of the iterative Delphi approach. Table 7 presents the GAW results from round 2, with the average increasing substantially from 71.1% to 80.2%. Most notably, Group G achieved 100% GAW, with all experts assigning exactly the same patterns to this group. The overall increase in GAW values demonstrates improved agreement on the composition of pattern groups after incorporating expert feedback. The decrease in GAW for Group C (from 65.6% to 45.8%) represents an interesting exception, reflecting expert reconsideration of pattern allocations in this area during the second round. This suggests that energy efficiency business models may have more complex relationships with other pattern groups than initially conceived. Overall, the round 2 results validate the final taxonomy structure while providing insights into the conceptual complexity of business model patterns in the electricity industry.

4.3 Industry alignment

To structure the pattern taxonomy, we followed prior research on the value chain (e.g. Gao *et al.*, 2011) and adopted a specific perspective on the electricity industry’s value chain, categorizing activities into two main types: primary activities, including generation, transmission, distribution, and services; and supplementary activities, including regulation and project financing. This value chain perspective is preferred to other perspectives in industry alignment as it explicitly includes regulation and project financing, which are critical to better realize industry dynamics in the electricity sector (Falchetta *et al.*, 2022). This is useful for managers to solve issues concerning a specific type of activity. Due to the specificity of all activities involved in the value chain, and the radical changes that are occurring in the sector, allocating the business model patterns along the value chain can guide managers to pay specific attention to activities that might need to be improved.

As was already exposed, the electricity sector has several specificities, so, in order to fully understand this industry, any assessment, including a business model taxonomy, must not be limited to the electricity generation side but should take into consideration the entire industry value chain.

Figure 3 presents the fifty-seven patterns mapped to specific activities in the electricity industry value chain, from energy generation (upstream) through transmission and distribution

Table 6. PAW percentages for Round 2

Pattern groups	Included patterns	PAW
Group A–Governance Modes	*A-09* - Cooperative Utility	100%
	A-23 - Local Aggregator	100%
	A-27 - Municipal Utility	100%
	A-34 – Active Customer	87.5%
Group B–Demand Side Management	*B-02* - Ancillary Service Market Participation	100%
	B-04 - Capacity Market Enabler	100%
	B-21 - Load Reduction	100%
	B-44 - Tailor-Made Retail Contracts	100%
	B-47 - Value-Added Enabler	100%
	B-54 - Energy data as a service (DaaS)	88%
Group C–Energy Efficiency Solutions	*C-08* - Comprehensive Energy Solution Providers	75%
	C-26 - Municipal ESCO	75%
	C-28 - Participation in Distributed Generation Markets	75%
Group D–Energy Generation	*D-18* - Green Energy Utility	100%
	D-24 - Market Performance Enhancement	75%
	D-32 - Power Plant Optimization	100%
	D-45 - Third-Party Ownership (TPO)	88%
Group E–Financing	*E-01* - Access to Cross-Subsidies	88%
	E-11 - Crowdfunding	100%
	E-12 - Direct Finance Options	100%
	E-13 - Energy Performance Contracts (EPC)	100%
	E-16 - Enterprise Credit Facilities	100%
	E-20 - Leasing	100%
	E-22 - Loans	100%
Group F–Energy Marketplace	*F-06* - Community Microgrid	100%
	F-15 - Energy Savings Certificates (ESC)	100%
	F-31 - Peer-to-Peer Energy Trading	100%
	F-51 – Local Market Operator	*100%*
	F-55 - Collective self-consumption	*88%*
	F-56 - Wholesale Market Participation	*100%*
Group G–Pricing Logic	*G-03* - Bundling	100%
	G-07 - Complementary Pricing	100%
	G-10 - Cost-Based Pricing	100%
	G-17 - Flat-Rate	100%
	G-36 - Rising Block Tariffs	100%
	G-46 - Time-of-Use Tariffs	100%
	G-57 - Power-Based Tariffs	100%
Group H–Revenue Models	*H-29* - Pay-as-you-go	100%
	H-30 - Pay-per-Use	100%
	H-33 - PPA (Power Purchase Agreement)	100%
	H-37 - Shared-Savings	100%
	H-41 - Space Rental	100%
	H-49 - White Label Retailing	88%
Group I–Storage Solutions	*I-05* - Could Energy Storage	88%
	I-19 - Large-Scale Energy Storage	100%
	I-38 - Small-Scale Energy Storage	100%
	I-42 - Storage Aggregator	88%
	I-43 - Storage Auctioning	100%
	I-52 - Using Cars to Store and Transport Energy P2P	100%

(*continued*)

Table 6. Continued

Pattern groups	Included patterns	PAW
Group J – Technology Enabler	*J-14* - Energy Price Monitoring Systems	100%
	J-25 - Microgrid	88%
	J-35 - Blockchain System Applications	88%
	J-39 - Smart Metering	88%
	J-40 - Software Applications	100%
	J-48 - Virtual Power Plant	100%
	J-50 - Charging System Operator	*88%*
	J-53 - Energy infrastructure/platform as a service (IaaS/ PaaS)	*100%*

Source(s): Authors' own work

Table 7. GAW percentages after Round 2

Group ID	Group name	GAW
G - A	Governance Modes	54.7%
G - B	Demand Side Management	85.7%
G - C	Energy Efficiency Solutions	45.8%
G - D	Energy Generation	75%
G - E	Financing	98.2%
G - F	Energy Marketplace	85.7%
G - G	Pricing Logic	100%
G - H	Revenue Models	76.6%
G - I	Storage Solutions	95.8%
G – J	Technology Enabler	84.7%

Source(s): Authors' own work

(midstream) to services and end-user applications (downstream), plus supplementary activities, including financing and regulation. This mapping helps organizations identify relevant patterns based on their position in the value chain.

Based on Figure 3, all patterns were assigned to a specific value-chain activity, which was defined based on their descriptions. For example, P18 "*Green Energy Utility*" is related to energy production, which refers to the use of power plants or generation units to convert various forms of energy into electricity. This pattern refers to the awareness about environmental issues, which leads customers to try to use more green energy.

In terms of transmission and distribution, they are two similar components. The only difference regards the power of the electricity network that they work with. These two activities refer exclusively to the transportation of electricity and do not include its sale to consumers. For instance, P50 "*Charging System Operator*" is linked to a system that enables electric vehicle users to charge their vehicles, while P38 "*Small Energy Storage*" is associated with the energy storage market for home-based and isolated applications.

Finally, the supply of energy or services is where the transactions with the end-users occur. In our study, several patterns were directly linked to this type of value-chain activity. P6 "*Community Microgrid*" concerns the social agreements, within a municipality or region of limited scope, to aggregate the acquisition and installation of microgeneration technology, and share the energy output for the installation. Regarding P29 "*Pay as You Go*", give companies several possibilities that provide financing options for new energy services and technologies directly to the consumer, which allows them to overcome cost issues. We also took into

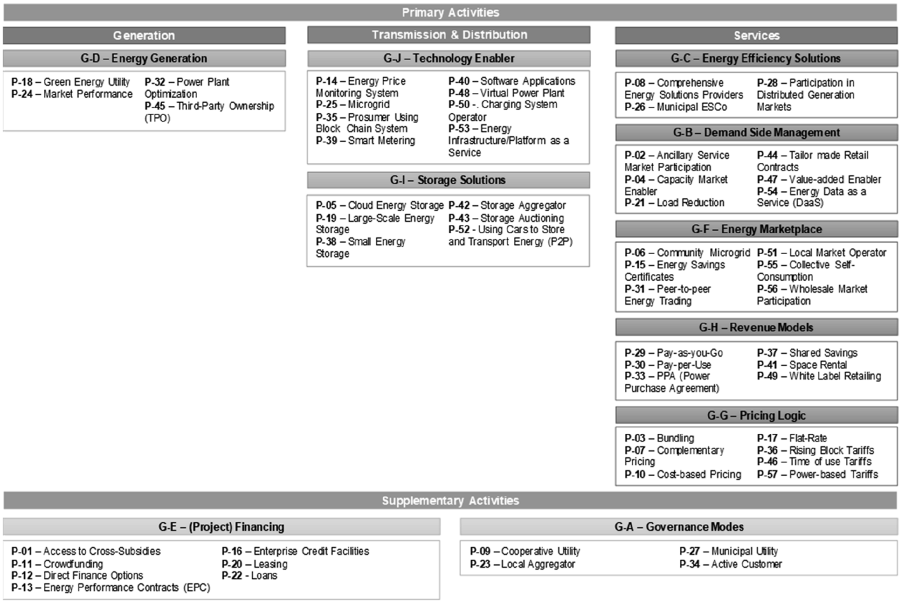

Figure 3. Business model patterns along the electricity value chain. Source: Authors' own work

account supplementary activities, which are more connected to financing and regulations. For example, P16 "*Enterprise Credit Facilities*" refers to how companies can get credit to finance energy projects.

In summary, the pattern taxonomy combined with the meta-level abstraction can be a helpful tool combination for firms that need to engage in business model innovation activities.

4.4 Pattern-based strategic mapping through the Three Horizons Framework

The business model patterns identified in this study help companies develop their primary business strategy, systematically manage innovation, and make informed and accurate strategic decisions. The developed patterns can also be complemented with strategic foresight tools such as the Three Horizons Framework, which characterizes the business growth planning process under three horizons (Horizon 1 on sustaining core businesses, Horizon 2 on new opportunities, and Horizon 3 on future innovations for long-term growth). As illustrated in Figure 4, in the context of business model innovation, the three horizons are translated into patterns that focus on improving core business models for Horizon 1, patterns that address adapting the business model for emerging markets for Horizon 2, and patterns that help develop disruptive business models for the future for Horizon 3. We also categorize the patterns across the electricity value chain from upstream (generation and supply of electricity) to midstream (transmission and distribution of electricity) to downstream (demand side of the value chain focused on retailers and customers). Building on prior research (e.g. Baue, 2019), the upstream-midstream-downstream value chain view is used for strategic mapping as it more effectively highlights the flow of value across the industry, facilitating the analysis of transitions, innovations, and evolving business model patterns over time. This perspective highlights market dynamics, value shifts, and evolving roles within the electricity sector, aligning well with the strategic focus of the Three Horizons Framework. In the following sections, we explain how the identified business model patterns can be mapped to specific innovation horizons.

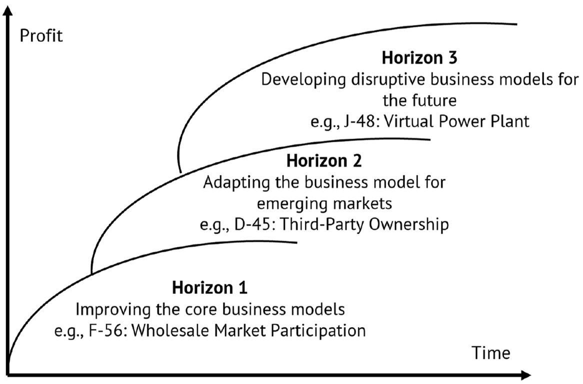

Figure 4. The three innovation horizons adapted to the business model context. Source: Authors' own work

4.4.1 Mapping business model patterns under horizon 1 innovations. Horizon 1 focuses on continuous innovation driven by the companies' core capabilities in the short term. In the context of business model innovation, Horizon 1 addresses business model patterns that improve the current business model for incremental developments such as optimization, operational efficiency, and cost control. As shown in Figure 5, our analysis shows that some of the identified business model patterns, such as F-56: Wholesale Market Participation (Dynamic competition among generators to auction electricity to retailers) can be applied in the upstream segment by players such as power generators that are more resource-constrained, require quick returns, and aim to continue serving existing customers, thus prioritizing incremental improvements over radical business model changes. For the midstream segment of the electricity value chain in Horizon 1, our analysis identifies some specific business model patterns, such as E−12: Direct Finance Options (energy providers offer credit to consumers for new technology/services). Finally, focusing on the downstream segment of the electricity value chain in Horizon 1, our analysis identifies specific business model patterns, such as

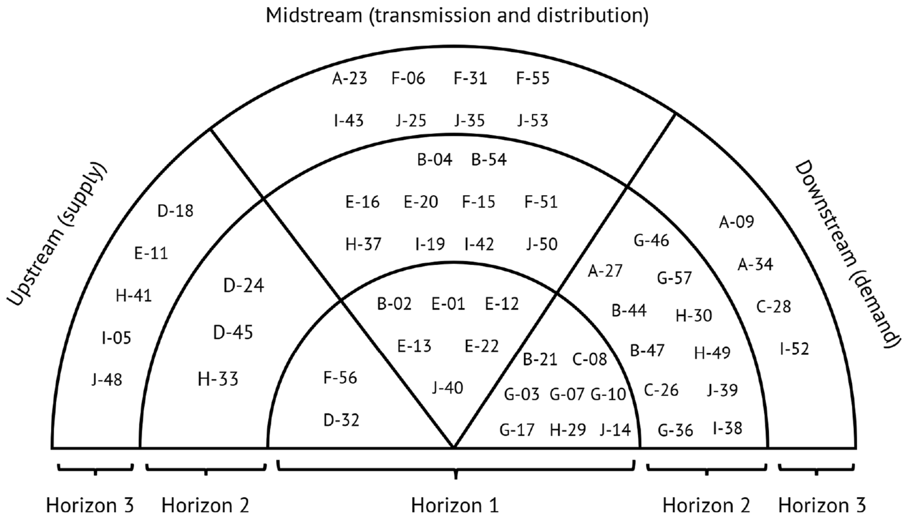

Figure 5. Mapping business model patterns across three innovation horizons. Source: Authors' own work

C-08: Comprehensive Energy Solution Providers (utilities shifting from basic energy supply to offering complete packages of energy services and technologies). For example, utilities in the United States (e.g. AT&T and Verizon Wireless) have begun to rebrand themselves as trusted energy advisors.

4.4.2 Mapping business model patterns under horizon 2 innovations. The second horizon corresponds to innovations in response to emerging opportunities that build on existing business infrastructure and capabilities but also apply new elements of growth. Focusing on the context of business model patterns, Horizon 2 emphasizes business model innovation practices that leverage existing business models while innovating individual building blocks of current business models. As shown in Figure 5, based on our analysis, some of the identified business model patterns under Horizon 2 are positioned in the upstream segment of the value chain focused on power generation. An example is the business model pattern D-45: Third-Party Ownership (TPO), where the energy producer offers to finance, install, and maintain a renewable energy system at the consumer's site, while retaining ownership of the technology and charging a fee for the supply of micro-generated energy. In addition, the analysis identifies Horizon 2 midstream business model patterns, such as F-15: Energy Savings Certificates (ESCs), where transmission system operators (TSOs) and distribution network operators (DSOs) can earn ESCs by implementing energy savings projects and sell "surplus" ESCs to other companies that need to meet regulatory energy savings targets. Finally, the analysis positions some business model patterns in the Horizon 2 downstream segment, such as B-47: Value-Added Enabler, where consumers can invest in demand-side management (DSM) systems that include energy efficiency products (e.g. insulation materials) or energy management tools (e.g. smart meters).

4.4.3 Mapping business model patterns under horizon 3 innovations. Horizon 3 involves radical innovation driven by transformational change that can redefine industries or create entirely new markets. Related to business model innovation, the third horizon involves the design and implementation of an entirely new business model that challenges the key characteristics and elements of the current business model. According to our analysis, with respect to the upstream segment of Horizon 3, some of the identified business model patterns recommend radical business model transformation processes for electricity producers. An example is business model pattern J-48: Virtual Power Plant (VPP), where a virtual power plant contracts in the wholesale market and provides services to the system operator. Regarding the midstream segment of Horizon 3, the analysis points to specific business model patterns targeting energy transmission and distribution companies that seek transformational business model innovation. For example, in the business model pattern, I-43: Storage Auctioning, energy storage capacity (e.g. batteries) is auctioned off to the highest bidder. As such, midstream companies with excess energy storage capacity can offer that capacity to others, such as energy producers or grid operators who need temporary storage to manage their energy supply. Finally, the analysis identifies some business model patterns in the Horizon 3 downstream segment, such as A34: Active Customer, where consumers can produce energy independently. This arrangement is supported by governments through a subsidy scheme known as a feed-in tariff.

In essence, Figure 5 represents the strategic mapping of business model patterns across The Three Innovation Horizons and Value Chain Segments. Pattern codes (e.g. F-56) refer to specific business model patterns where the letter indicates the pattern group (as defined in Table 2), and the number identifies the specific pattern within that group. Horizon 1 patterns (bottom layer) focus on core business optimization with short-term returns, Horizon 2 patterns (middle layer) address emerging market opportunities with medium-term innovation potential, and Horizon 3 patterns (top layer) represent transformative future business models with long-term strategic impact. Patterns are distributed across upstream (generation), midstream (transmission and distribution), and downstream (retail/consumer) segments of the electricity value chain to facilitate targeted business model innovation.

5. Discussion and conclusion

In this study, we set out to understand how firms can innovate their business models through an industry-specific business model pattern taxonomy at the example of the electricity industry. Considering the lack of understanding of how business model patterns can be beneficial to a specific industry, we explored how a taxonomy-building approach (Lüdeke-Freund *et al.*, 2018a) could be also applied to develop an industry business model taxonomy for our industry context, which represents the state-of-the-art value creation and capturing mechanisms in this sector. Initially, 49 patterns were identified, described in a standardized way, and allocated into ten groups. The entire list and descriptions were sent out to eight experts, who, after two rounds, suggested adding eight new patterns, resulting in a list of 57 business model patterns (see the full description of all the business model patterns in the supplementary material). Through an open card-sorting method, a consensus was reached among all experts. Subsequently, we aligned the 57 patterns along the value chain. All patterns were assigned to a specific type of activities that relate to energy generation, transmission and distribution, and services (primary activities), or to the supplementary activities which concern regulations or financing. Finally, we introduced a framework based on the Three Horizons Framework of innovation and value chain segments, through which companies can better position the business model patterns they need most.

Overall, the findings of this study reveal not only a comprehensive taxonomy of 57 business model patterns but also their strategic relevance when mapped onto the Three Horizons Framework (Curry and Hodgson, 2008), underscoring the dynamic evolution of the electricity industry. The application of strategic mapping (Thomas *et al.*, 2024) and hence allocation of patterns across the three horizons highlights how companies can simultaneously optimize current operations (Horizon 1), scale emerging opportunities (Horizon 2), and explore transformative innovations (Horizon 3). This is in line and adds to the findings of previous studies (e.g. Garlet *et al.*, 2020) that apply strategic mapping tools for exploration of innovation diffusion and adoption. This systematic approach reflects the complex balancing act required for successful business model innovation in a rapidly changing sector, such as the electricity industry. For instance, the concentration of optimization-focused patterns in Horizon 1 emphasizes the ongoing need for efficiency in established value chain segments, whereas Horizon 2’s patterns illustrate the critical shift toward growth via novel market and technological applications. Horizon 3’s transformative patterns point to emerging systemic changes that could disrupt traditional industry structures, suggesting that firms must invest in exploratory initiatives to remain competitive in the long term. Contributing to recent studies that use the Three Horizons Framework (e.g. Osei-Amponsah and Abdulai, 2025), our business model pattern categorization not only enriches theoretical understanding by linking business model innovation (Sanasi, 2023) with strategic foresight frameworks (Thomas *et al.*, 2024) but also provides practical insights for managers to prioritize innovation efforts aligned with industry-specific challenges.

The distribution of patterns across our 10 thematic groups provides additional insights into electricity sector value creation dynamics. The substantial representation of Technology Enabler patterns (8 patterns) compared to Energy Efficiency Solutions (3 patterns) suggests that digitalization is driving more business model innovation than efficiency optimization alone. The prominence of both Financing (7 patterns) and Revenue Models (6 patterns) underscores the sector’s capital-intensive nature, where financial mechanisms often become the primary source of business model differentiation. Notably, the emergence of Storage Solutions as a distinct group (6 patterns) reflects energy storage’s evolution from a technical component to a fundamental business model enabler, while the separation of Demand Side Management from Energy Generation signals the industry’s strategic shift toward demand-side value creation.

The outcomes of our research have implications for both the research and practice of business model innovation. They highlight the need for a new research stream focused on business model patterns for energy firms seeking digital transformation, sustainability, and competitiveness. In the next subsections, we discuss these implications and future research opportunities.

5.1 Theoretical implications

Our study adds to the literature on business model innovation in general (Abdelkafi *et al.*, 2013; Evans *et al.*, 2017; Johnson, 2010; Linder and Williander, 2017) and the energy sector in particular (Burger and Luke, 2017; Facchinetti and Sulzer, 2016; Hall and Roelich, 2016) by exploring the context of business model pattern taxonomies (e.g. Weking *et al.*, 2020) in the renewable energy sector. We contribute to the understanding of the reconfiguration of certain business model building blocks (Bitetti and Bedolla, 2024; Chasin *et al.*, 2020a, b) by identifying business model patterns that focus on specific aspects, such as the financial model in Groups G and H (see supporting material). The results also help to better map the value chain of the energy sector (Burger and Luke, 2017; Hall and Roelich, 2016) by identifying business model patterns based on the characterization of the value chain, such as demand-side management in group B and energy production in group D. Not least, we contribute to a better understanding of energy efficiency adaptation in the electricity sector (Foulds *et al.*, 2017; Helms *et al.*, 2016) by identifying business model patterns for efficient electricity processes, such as energy efficiency solutions in group C by participating in distributed generation markets.

We extend existing typology efforts related to business models (Kubli and Puranik, 2023; Lüdeke-Freund *et al.*, 2019; Weking *et al.*, 2020) by developing a set of business model patterns categorized into 10 different themes based on various aspects of the business environment in which energy companies are involved. This provides new, distributed ways of creating and capturing value compared to existing business model perspectives that view value and companies as a “whole” (Bowman and Ambrosini, 2000). Our findings guide future research on the application of business model patterns to emerging digital transformation technologies such as IoT (Pérez-Arriaga and Knittel, 2016), smart home systems (Chasin *et al.*, 2020a, b), blockchain (Weking *et al.*, 2020), and big data analytics (Amshoff *et al.*, 2015). The 10 identified themes of business model patterns extend the current business model theories beyond the traditional focus on physical value propositions (Chesbrough, 2006). This means that identifying business model patterns for specific organizational contexts requires a different perspective. For example, for energy companies serving specific customer segments, in the case of this study, conscientious customers concerned about the production and consumption patterns of their local energy community, certain business model patterns, such as a cooperative utility, would work better.

Our electricity-specific taxonomy also reveals important distinctions when compared to business model patterns in adjacent industries. While telecommunications business models emphasize platform orchestration and network effects (Remane *et al.*, 2017), our electricity patterns stress distributed generation, storage solutions, and regulatory compliance, reflecting the fundamental differences between managing data flows versus electron flows. Similarly, while generic business model taxonomies focus primarily on revenue mechanisms and customer relationships (Gassmann *et al.*, 2014), our electricity-specific framework necessarily emphasizes infrastructure coordination and real-time balancing requirements. The emergence of distinct ‘Energy Marketplace’ and ‘Technology Enabler’ groups appears unique to electricity, reflecting the sector’s simultaneous digitalization and decentralization, a dual transformation less pronounced in traditional utility sectors.

This study further contributes to the business model literature by applying the Three Horizons Framework. Extending the work of previous studies that investigate business model innovation by identifying existing business model patterns (Abdelkafi *et al.*, 2013; Amshoff *et al.*, 2015; Facchinetti and Sulzer, 2016), investigating the combination of business model patterns for sustainable business models (Abdelkafi *et al.*, 20–23), exploring the design choices and consequences that enable certain business model patterns (Bitetti and Bedolla, 2024), and developing conceptual tools for creating innovative business models based on existing patterns (Lüttgens and Diener, 2016), this study systematically mapped business model patterns across different time horizons to understand how they transition from established models to future-oriented innovations.

The approach taken in this study can be followed by other researchers to create and collect business model patterns for different industries. This taxonomy-building approach, along with strategic mapping within the Three Horizons Framework, can be useful for several areas of the energy industry to consolidate and frequently update new business models, thus simplifying the ideation process of energy managers. Last but not least, the proposed Alexandrian description facilitates the formation of a common business model pattern language (Lüdeke-Freund *et al.*, 2018b).

5.2 Practical implications

Given the impact of digital transformation technologies in the electricity industry, the identified business model patterns can be used to apply AI and machine learning, for example, to identify and suggest the most appropriate patterns for energy companies based on their specific circumstances, market environment, and business ecosystem. AI and machine learning can be integrated with custom enterprise data as a powerful method to provide tailored and contextual solutions to energy company problems. Although business model patterns have already been used in practice for various purposes, such as sustainability by design solutions (Bitetti and Bedolla, 2024) or the impact of emerging technologies such as smart home IoT connectivity (Chasin *et al.*, 2020a, b) and blockchain-based systems (Weking *et al.*, 2020) on business model innovation, there is still a lack of structured guidance to help managers in their business modeling process. The business model patterns developed in this study will hopefully guide managers in the business model innovation process in the electricity industry. Structuring business model patterns based on the Three Horizons Framework and value chain segments helps ensure that patterns are created and extended in a consistent manner, and that these patterns are easily accessible and reusable by practitioners.

The business model patterns identified in this study represent innovative and valuable approaches to designing and implementing new business models in the energy sector. The three-step methodology, including pattern creation, pattern validation, and industry specification, resulted in a systematic set of patterns along the electricity value chain, from energy generation to financing and governance modes. The integration of business model patterns and foresight tools such as the Three Horizons Framework offers a promising resource for managers in business model design and implementation. These tools can help identify relevant business model patterns, generate innovative strategies, and provide tailored recommendations based on the input data (e.g. the patterns). This contributes to faster and more accurate decision-making, increased creativity in strategy development, and a more systematic approach to exploring new business model opportunities.

The applicability of our taxonomy extends beyond the electricity sector, offering practical value for adjacent industries. Certain pattern categories demonstrate high transferability potential, particularly those addressing fundamental business mechanisms. Patterns related to financing mechanisms (Group E) and pricing structures (Group G) contain core business principles applicable across utility-based industries such as heating, water utilities, or telecommunications (Gassmann *et al.*, 2014; Weking *et al.*, 2020). For instance, “Direct Finance Options” (P12) and “Time-of-Use Tariffs” (P46) address universal challenges of capital access and demand management present in most infrastructure-based services (Oseni and Pollitt, 2017; Helms *et al.*, 2016). Conversely, patterns specifically tied to electricity infrastructure would require adaptation for other contexts. Regional transferability is another practical consideration; patterns involving regulatory frameworks (e.g. “Energy Savings Certificates”, P15) require reconfiguration to align with local policy environments (Hall and Roelich, 2016). Organizations in adjacent sectors can use our taxonomy as a starting framework, adapting patterns to their specific technological and regulatory contexts (Baden-Fuller and Morgan, 2010; Remane *et al*., 2017), potentially accelerating their business model innovation processes by leveraging proven solutions rather than starting from scratch.

5.3 Implementation challenges for business model patterns

While our pattern taxonomy provides strategic guidance, implementing these patterns presents several critical challenges for electricity companies.

First, institutional inertia poses significant barriers, particularly in established utilities with legacy infrastructures and traditional operational models. Patterns requiring fundamental shifts in organizational thinking, such as "Active Customer" (P34) or "Peer-to-Peer energy Trading" (P31), often encounter cultural resistance beyond merely technical implementation difficulties (Sun *et al*., 2024).

Second, capability gaps present practical impediments, especially for technology for technology-intensive patterns. Implementing "Blockchain System Applications" (P35) or "Virtual Power Plant" (P48) requires specialized expertise that traditional utilities may lack, necessitating either capability development or strategic partnerships with technology providers (Weking *et al*., 2020).

Third, regulatory constraints vary across markets, with some patterns facing legal barriers in certain jurisdictions. The complexity of electricity market regulations requires careful assessment of regulatory feasibility before significant investment in pattern implementation (Bell and Gill, 2018).

The nature of implementation challenges varies across the Three Horizons. Horizon 1 patterns typically face operational challenges within existing frameworks. Horizon 2 patterns encounter both operational and strategic challenges as companies balance current operations with emerging opportunities. Horizon 3 patterns often require comprehensive organizational transformation and strategic foresight, qualities often underdeveloped in traditionally stable utility organizations. Furthermore, timing considerations significantly impact success; early adoption may encounter immature ecosystems and regulatory uncertainty, while delayed adoption risks competitive disadvantage as more agile competitors establish market positions.

These challenges highlight that pattern identification represents only a first step in the business model innovation process. Successful implementation requires complementary capabilities in change management, regulatory engagement, and organizational adaptation, dimensions essential for translating pattern-based strategies into market success.

5.4 Research limitations and future directions

First, the initial model defined by the seed participants influences the methodology used. Therefore, the selection of qualified seed participants was important for the robustness of the study. Second, the card-sorting exercise can be an arduous task for experts and hence bears the risk of fatigue that may lead to taking shortcuts. Selecting committed experts and making the process as smooth as possible mitigate this risk. Finally, the third phase, industry alignment, was conducted by the author team and, therefore, it may be biased. In the future, we suggest a final consultation with the experts.

The potential subjectivity in the industry alignment phase of our taxonomy development does not affect the validity of the findings as the developed taxonomy is based on a rigorous multi-phase methodology that includes extensive literature review and expert input in earlier phases. However, to mitigate the potential risk of author bias and other limitations mentioned above, one of the authors carefully reviewed the taxonomy and cross-checked the patterns with recent studies on the development of business model patterns included in the literature review section. Finally, one limitation of this study was the generalization of the business model pattern taxonomy beyond the electricity sector or to regions with different market conditions. Therefore, its applicability to other energy sectors or contexts requires careful adaptation.

We recommend that future researchers investigate the potential beyond business model innovation and the applicability to other areas of innovation research, including new product development, process innovation, technological innovation, open innovation, and sustainability-oriented strategies such as green innovation (Bamel *et al.*, 2022; Sá *et al.*, 2023). The identified business model patterns can be further conceptualized and operationalized by exploring the constituent building blocks (Andreassen *et al.*, 2018) and underlying interdependencies (de Oliveira and Cortimiglia, 2017).

Future research may wish to explore the configuration patterns of the elements identified in the business models, and how these influence business performance (Gerdoçi *et al.*, 2023; Massa *et al.*, 2017). Further research is required to investigate the manner in which these patterns vary in accordance with the context, specifically the industry, at the stages of design (Zott and Amit, 2010) and implementation (Zott *et al.*, 2011) of business models. These new business model patterns can be viewed as an organizational process (Teece, 2010), allowing future research to investigate both the antecedents and consequences of the transition towards these business models.

The potential of emerging technologies, such as generative AI, to trigger new business model patterns in diverse industries, including electricity, represents a topic of ongoing research interest. Finally, it is crucial to examine how these novel business model patterns can contribute to sustainable development in social and environmental contexts.

6. Conclusions

This study has developed a comprehensive business model pattern taxonomy for the electricity industry, identifying and validating 57 patterns organized into 10 meaningful groups. Through a structured methodology involving pattern creation, validation with industry experts, and alignment with the electricity value chain, we have created a framework that bridges theoretical understanding with practical application. The integration of these patterns with the Three Horizons Framework offers a strategic mapping approach that distinguishes between short-term operational improvements, medium-term emerging opportunities, and long-term transformative innovations across upstream, midstream, and downstream segments of the electricity value chain.

The business model pattern taxonomy presented in this study represents a response to the fundamental changes occurring in the electricity industry, where digitalization, increasing renewable energy adoption, and market liberalization are creating both challenges and opportunities. By providing a structured approach to business model innovation through identified patterns, this research contributes to the industry's ability to navigate these changes while developing innovative configurations that create and capture value in novel ways appropriate to different time horizons and market positions.

Note

1. Directive (EU) 2019/944 of The European Parliament and of the Council. Article 2 "active customer' means a final customer, or a group of jointly acting final customers, who consumes or stores electricity generated within its premises located within confined boundaries or, where permitted by a Member State, within other premises, or who sells self-generated electricity or participates in flexibility or energy efficiency schemes, provided that those activities do not constitute its primary commercial or professional activity. Also, Article 15 states that "Member States shall ensure that final customers are entitled to act as active customers without being subject to disproportionate or discriminatory technical requirements, administrative requirements, procedures and charges, and to network charges that are not cost-reflective".

Supplementary material

The supplementary material for this article can be found online.

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