# The Blockchain Marketplace as the Fifth Type of Electricity Market

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**Abstract.** This paper tackles today's unprecedented challenges of enabling and stimulating multiple energy stakeholders to have a more active participation in the smart grid electricity market. The research extends the existing four archetypes of orchestrator-driven business models for the electricity market and proposes a fifth type of electricity market, the Blockchain Marketplace. The key novelty of the paper is to expand the electricity market architecture and design from centralization and pseudo-decentralization to full decentralization, enabled by the blockchain. The study not only broadens the smart grid and electricity market literature but also contributes to the theoretical development of the business model and organization study domains with a systemic approach.

**Keywords:** Electricity market · Blockchain · Business model
Smart grid

## 1 Introduction

The energy industry used to have a simple business model. Fully integrated electric companies used to be the center of the industry, building transmission and distribution networks for the constantly growing demand. Energy utilities decided when and where to invest and build generation capacities; they decided how to maintain the system in balance, acting as a centralized controlling entity.

However, the world is changing and electric systems have been undergoing significant changes [1]. The current electrification state of the world is at 85.3% [2]. The growing energy demand and dependence on fossil fuel has become a global issue [3]. Simultaneously, the integration of large volumes of distributed energy resources (DERs) has posed unprecedented challenges to maintaining the balance of generation and demand as well as planning and operations of concurrent electric infrastructure [4].

It is urged by [5] that a global technological revolution is changing the power balance between consumers and centralized utilities. The increasing growth in DER is moving the power balance from integrated utilities to the demand side, where consumers have control over a more sustainable, more local, and more resilient energy


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system. Numerous studies address the need to move this revolution into the mainstream and create a new model or design for the energy market that puts consumers in charge of a co-created energy future [6, 7].

The European Union (EU) just announced the ambitious “Clean Energy for All Europeans” package [8], demanding “an increase in the energy efficiency target from 27% to 30%, a cut in emissions by 40%, and a goal of 27% renewables in final consumption, all by 2030”. Thus, a key question is how to enable energy stakeholders (e.g., consumers, prosumers, DERs, utilities) to have more active participation in the energy market, facilitating the evolution of energy system to save the planet while creating more value for the market participants.

The blockchain, developed first for the Bitcoin cryptocurrency [9], is a decentralized transaction and data management technology and a distributed database solution maintaining growing data records that are confirmed by the nodes participating in it [10]. Industry-specific blockchain use cases are being identified in different fields, such as finance [5], telecommunication and spectrum sharing [11], and the Internet of Things (IoT) [12]. The research of [13] focuses on the blockchain’s application in energy, identifying use cases like solar trading in the US, energy exchange in Austria, and the billing process for autonomous electric vehicle charging stations in Germany.

This paper aims at contributing to the research on new electricity market design and business models as follows: (1) the paper studies the most recent theoretical development of the business model, resource configuration, and organization design literature for the systemic design of the electricity market in the digital age; (2) the research elevates the extant four archetypes of resource configurations (orchestrator-driven, from centralization to pseudo-decentralization) to a systemic logic (system-driven, full decentralization) that was not there in the previous literature; (3) from the business model perspective, the study proposes a fully decentralized electricity market design enabled by the blockchain or the so-called “Blockchain Marketplace” as opposed to the centralized and pseudo-decentralized electricity market design in the existing literature.

The paper is composed as follows: In Sect. 2, the paper provides a characterization of the four established resource configuration business model archetypes. Section 3 provides a concise description of the blockchain technology. Section 4 describes the research methodology and data collection. Section 5 constructs a blockchain-based business model archetype for the future energy market by first discussing the identifiable applications of the four archetypes in the energy market as the context and then proposing the concept of a fifth electricity marketplace. Section 6 provides a concluding discussion on implications and limitations and a recommendation for future studies.

## 2 The Four Archetypes of the Business Model

Business model research has expanded during the last decades [14]. The business model has been studied as a system/collection of interdependent components such as resources and competence, internal and external organizational structures [15], customer value proposition [16], and cost and revenue structure [17]. Only recently, a converging conceptualization, incorporating three key processes for business models that connect them to the context, opportunity processes (exploration, exploitation) [18], value processes (creation, capture) [19], and advantage processes [7], has emerged in the scientific community.

Other business model discussion streams have focused on the discovery or design of successful business models. The literature shows that viability (robust performance [20]), sustainability (technical-, social- and environmental-oriented [21]), and scalability (scalable deployment capability [22] and profitable growth [23]) are essential to business model success as “a better way than the existing alternatives” [24].

In the pervasive digital age, the scope of resources that a company can utilize and access has expanded. A holistic approach is required to enhance value creation and capture from [25]’s “added-value” strategy to the latest business model discussions on value centricity [26] and systemic value [7] for digital business models. Building on these latest approaches and resource orchestration [27], this paper first opens up the four archetypes of orchestrator-driven business models before diving into the fifth archetype in Sect. 4:

- **The first archetype—“company as an integrator”:** The focal orchestrating firm (O) transforms resources to create value for customers. This has been the predominant type of resource configuration for traditional companies like manufacturers, studied in the light of established theories [27].
- **The second archetype—“company as a collaborator”:** The orchestrating firm (O) collaborates with partners who have complementary resources as a value-creating resource configuration. This archetype is recognized in strategic alliance [28] and ecosystem studies [29].
- **The third archetype—“company as a transaction enabler”:** This is associated with the platform business model, meaning that broader and easier access to resources allows the orchestrating firm (O) to build two or multi-sided markets to match resources and needs.
- **The last archetype—“company as a bridge”:** This shows that the proliferation of virtual resources (such as data) creates the opportunity for an orchestrating firm (O) to bridge certain groups of market participants that have not been previously connected, based on the data and benefiting from bridging unconnected needs, such as Google’s advertising model [26].

## 3 Blockchain and Smart Contract

According to [30], the idea to collaboratively consume, share, and decentralize resources or assets among different peers can be seen in various concepts such as the Sharing Economy [31], Collaborative Consumption [32], and the Peer-to-Peer (P2P) Economy [33]. Blockchain technology is identified as the enabler for such a fully decentralized system [30].

Blockchain is a general-purpose decentralized transaction and data management technology, developed first for the Bitcoin cryptocurrency [9], with the ability to track transactions, settle trade deals, and enforce contracts across a wide range of digital assets which in turn can represent currency, IP, data, contracts or physical assets [34].

In practice, a blockchain is a distributed database solution maintaining a continuously growing list of data records that are confirmed by the nodes participating in it. The data is recorded in a public ledger, including information about every transaction completed. A blockchain network is a peer-to-peer (P2P) network that does not require a third-party organization in the middle. As no central server or intermediary is in place, a consensus mechanism is needed for ensuring the coherency of data between the nodes. There are several consensus mechanisms under discussion, e.g., [35, 36]. Furthermore, in the blockchain, the utilization of cryptography enables authoritativeness behind all interactions [37]. Information about every completed transaction is shared and available to all nodes, which makes the system more transparent than centralized solutions [38]. The extant literature claims that the blockchain is embodied in a combination of existing technologies, including peer-to-peer networks, cryptographic algorithms, distributed data storage, and decentralized consensus mechanisms [30].

Smart contracts (SC) operate as autonomous actors with self-executing scripts that reside on the blockchain, enabling general-purpose computations occurring on the chain to be fully predictable [37]. The SC concept was introduced in 1994 [39], defined as a computerized transaction protocol that executes the terms of a contract. The SC code and the cryptographically verifiable trace of the SC's operations can be inspected by all the network participants. SC enables the automation of complex multi-step processes and proper, distributed, heavily automated workflows [37]. They have many applications in different domains, enabling, e.g., decentralized applications like voting, auctions, lottery, escrow systems, crowdfunding, and micropayments [40].

It is suggested by [41] that the blockchain technology is poised to improve the smart grids that incorporate communication technology and sensors. This can range from super grids that connect large-scale energy systems (e.g., storage) to microgrids that are designed for connecting DERs. In fact, a number of blockchain energy initiatives are emerging globally, such as the Brooklyn Microgrid [42].

The antecedents of blockchain-enabled electricity trading and marketplace can be found in both the conceptual and empirical realms. For instance, peer energy trading is one of the highly promising areas for the Blockchain Marketplace [42]. Conceptually, a case of decentralized sharing in photovoltaic (PV) generation is proposed by [41]. The conceptual use case investigates the autonomous optimization and energy trading among different systems (including heating, cooling, hot water storage, and energy storage), which resembles a localized machine-to-machine electricity market.

The Brooklyn Microgrid is an empirical example where household residents trade energy among themselves. This blockchain platform provides the technical infrastructure for the local electricity market. Prosumers and consumers can submit, buy, or sell electricity orders to the market through the pre-defined market mechanism [42].

GrünStromJeton is another case studied in the European Commission's report [43]. GrünStromJeton provides an index that indicates the relative production of energy from alternative renewables during the next 36 h. The system monitors and records the energy consumption of the customers and rewards consumers when they use renewable energy sources. This is a trading mechanism between GrünStromJeton's digital system and the actual consumers.

## 4 Research Methodology and Data Collection

This study adopts the action research methodology within techno-social innovation research as part of a major EU energy innovation project on a P2P trading platform that enables and supports a decentralized energy market design and the P2P energy exchange of smart grids. According to [44], the action research methodology leads to producing scientific knowledge that can serve the actions, which enables the formalization and contextualization of models and tools, facilitating the production of new knowledge and enabling organization change.

The research was conducted in two steps: First, the study embarks on a systematic analysis of 50 innovative business cases with various types of business models in the energy and smart grid industry. The data was collected from the European Commission's BRIDGE initiative, uniting 31 major European smart grid and energy storage projects. The collected data is in the form of business model examples, which are contributed by international energy experts, energy companies, regulators, and research organizations. The comprehensive collection of business model data enables a thorough analysis of business model archetypes in the energy industry, avoiding common selection bias [45].

The second step utilized the business model design framework used by [26] on resource configurations for digital business. This study adopted a systemic and value co-creation centric perspective that considered the needs (N), the resources (R), and the created value (V-C) of all value co-creators in the energy industry. Such an approach is grounded in the literature of resource orchestration [27] and business model design [20].

## 5 The Fifth Archetype of the Business Model for the Electricity Market

In this section, the **four archetypes of orchestrator-driven business models in the electricity market** are first presented as four prototypes (Fig. 1).

**Prototype A: The Centralized Utility Model.** This is the traditional utility business model which assembles a "company as an integrator". It has the simplest resource configuration, where a traditional integrated utility (orchestrator) converts the generation fuel (e.g., coal, natural gas) as resources ($R_{CU}$) to address the consumer's electricity consumption as demand ($N_1$). Consumers contribute to the business need utilities ($N_{CU}$) as revenue with financial resources (payment for an electricity bill) ($R_1$). It is argued by [6] that this prototype makes very little space for the growth of DERs and local demand services and gives poor support for energy efficiency.

**Prototype B: The Disintegrated Retailer Model.** A disintegrated retailer model is defined by [6] as an organization that does not own generation assets (such as power plants), instead partnering with one or more generators and using its own brand. It is a common business model for electricity retailers in liberalized markets. As a Prototype B utility, the orchestrating retailer company collaborates with a partner with generation assets (V-$C_2$) to supply and service the needs of consumers ($N_1$). The

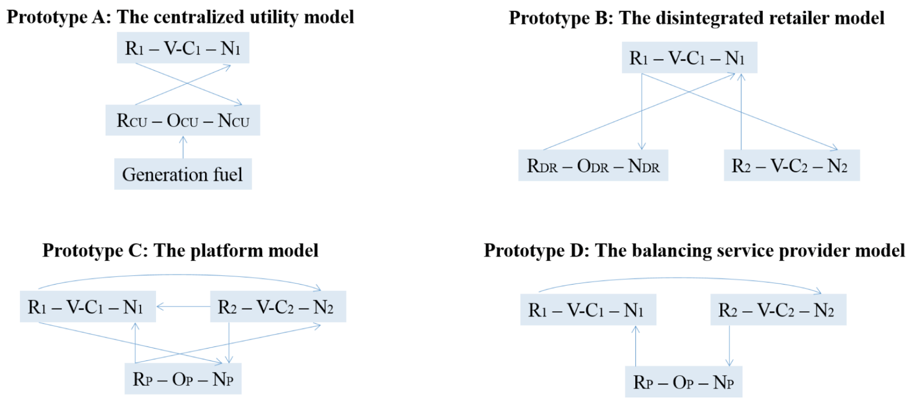


**Fig. 1.** The four archetypes/prototypes of business models in the energy market.

resources to meet the consumption ($R_{DR}$ and $R_2$) are not solely from the disintegrated retailer but are contributed by its partners. Thus, the role of a Prototype B company is not a resource transformer as in Prototype A, but a collaborator who engages another "complementor" ($V$-$C_2$) [29] to create value for energy consumers ($V$-$C_1$).

**Prototype C: The Platform Model.** The platform research was pioneered by [46]. Cambridge researchers [47] initiated the discussion of the platform business model in the energy market. A platform operator brings together groups of users and providers of products and services, mediating their interaction and matching needs. A key feature of the platform market is the existence of the network effect: the value of the platform changes with respect to the participation rates on the same side and the cross side [47]. In the energy market, the platform operator (orchestrator) contributes resources ($R_P$) to enable interactions and matchmaking between two groups of value co-creators (such as consumer and prosumer) whose needs ($N_1$ and $N_2$) can be matched by each other's resources ($R_2$ and $R_1$). Thus, the platform operator facilitates energy trading between consumers and prosumers as well as among several prosumer groups.

**Prototype D: The Balancing Service Provider Model.** Balancing market is defined by [48] as the institutional arrangement that establishes market-based balance management in an unbundled electricity market. The business model for the balancing service operator can be a virtual power plant (VPP) [44] or a local balancing unit [6]. A balancing service provider adopts a Prototype D business model, using its resources (RBSP) such as a digital solution to provide energy efficiency services for the needs of consumers ($N_1$). As an orchestrating entity, the balancing service provider utilizes consumption data and patterns collected from the consumer ($R_1$) to address the needs of another group ($N_2$), such as the distribution network operators (DSOs). Thus, the balancing service provider enables DSOs to leverage the consumption data and behaviors controlled by the consumers to balance the electricity network.

### 5.1 The Fifth Type of Electricity Market, the Blockchain Marketplace

In a blockchain-enabled market, the blockchain operates as a chronological, immutable, and trusted data storage. The smart contracts generated by the blockchain can automate offer testing and modification based on the parameters tuned in the feedback loop.

Based on the above discussion, Fig. 2 shows the simplest form of the blockchain-enabled marketplace without the need of an orchestrator. The existence of the blockchain and smart contract allows any participant in the energy market, such as participant 1, to match its $N_1$ with the $R_2$ of participant 2 (such as the case of energy and flexibility trading), while the $R_1$ (e.g., the financial payment) is directed to $N_2$ without an orchestrator standing between the direct value co-creation and co-capture. In contrast, with the orchestrator-driven models (Fig. 3), a portion of the value flows out of the direct value co-creation and is captured by the orchestrator. Theoretically, in the Blockchain Marketplace, there is no value flowing out of the direct value co-creation and market participants are better off with more value accrued and shared.

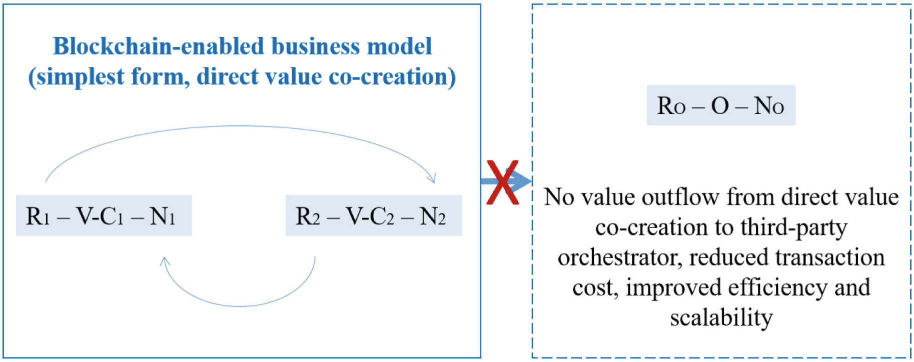


**Fig. 2.** The simplest form of a blockchain-enabled marketplace.

According to [49], transaction costs are fundamentally interrelated with distrust. As a micro process of the business model [26], trust as one of the key characteristics of the blockchain facilitates the resource crowdsourcing process by providing lower transaction costs. The costs of verification and networking can be radically reduced through the blockchain [34], while the parts of the transaction that concern negotiating, establishing, and enforcing the transaction may be automated as smart contracts operating on behalf of value co-creators, making and accepting tenders, matching needs and resources. Instead of a centralized orchestrator, the Blockchain Marketplace can automate large amounts of decentralized transactions, reducing transaction costs, increasing direct value co-creation flows, and improving efficiency and scalability with no need for a third-party intermediary, as shown in Fig. 3.

Based on a trusted data set provided by the blockchain, prospecting and sorting algorithms can be used for further tuning the business processes in a Blockchain Marketplace for the energy industry. To mitigate general privacy risk of the blockchain

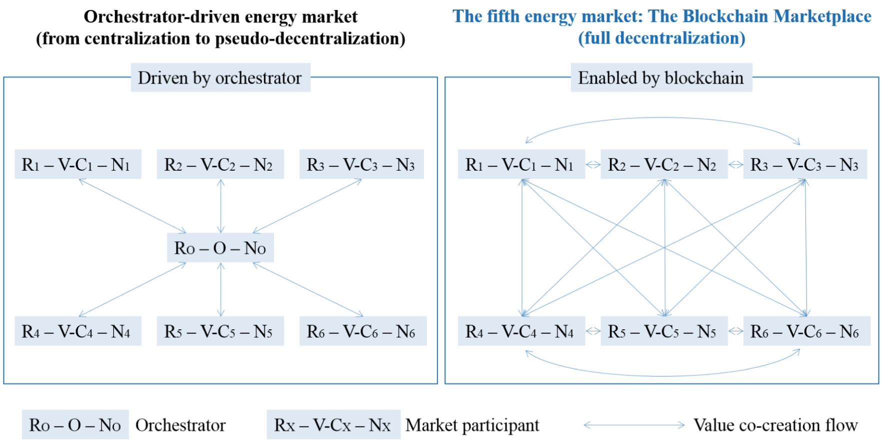


**Fig. 3.** Comparing the orchestrator-driven energy market and the blockchain marketplace.

technology related to gathering extensive data sets, new secure privacy-preserving encryption methods are being developed, such as [50, 51].

As part of the process, the blockchain can also facilitate the novel grafting of resource combinations and configurations, streamlining and fine-tuning the smart contract parameters controlling the relationship between energy market participants, and combining data analysis tools with the digital blockchain platform to enrich novel complementarity created in the grafting process.

## 6 Concluding Remarks

This paper uses the resource configuration approach to propose the fully decentralized business model archetype for a blockchain-enabled electricity market, pointing out that despite the continuous liberalization effort of the regulation, the electricity market design and business model remains a centralized scheme or a pseudo-decentralization at its best. It identifies how the blockchain as a new technology or technical development can affect the market design of electricity, contributing the business model perspective to the extant energy and electricity market literature.

The **theoretical contributions** of the study are as follow: The resource configuration approach explains how a company can create and capture value through strategically configuring the resource [27, 52], which is further embodied in business model studies with the latest classification of four business model archetypes [26]. This study identifies that the four archetypes are only sufficient to depict orchestrator-driven business models, since all the archetypes require an orchestrating entity to enable or facilitate the value co-creation while extracting part of the value to meet its own needs (such as revenue and profit).

To tackle the aforementioned (research) gap, this study looks into the fully decentralized business model concepts and proposes the Blockchain Marketplace as a fifth business model archetype for the energy market, and the only archetype that is not orchestrator-driven and promising full autonomy for the market participants. The theoretical contribution of the paper is not limited to energy market design; it also contributes to management and organization studies in general through systemic thinking about how resources are configured, how value is created, and how market participants' needs are met, regardless of the existence of a resource-orchestrating entity. An industry or ecosystem can be formulated from pseudo-decentralization (as managed by an orchestrating entity) to full decentralization (as enabled by the blockchain).

Regarding the **empirical contributions**, the blockchain is expected to change and affect the centralized legacy systems with full decentralization, enabling microgrids, DERs, renewable integration, P2P energy trading and higher consumer/prosumer engagement, managing less predictable and more volatile renewable power sources in the future. The empirical goal is to help the energy industry to re-think value creation, breaking the boundaries and constraints of contemporary energy market design logic, enabling the discovery of new design patterns for innovative resource configuration for a future-oriented electricity market.

This study is limited and focused on the conceptualization of the Blockchain Marketplace. The micro processes of the business model development are only briefly touched upon in the paper. In the future, the micro processes for the development of this new business model archetype need to be further studied and discussed to shed light on how the fifth type of electricity market, the Blockchain Marketplace, functions. The further development of this new archetype through simulation and quantitative methods is recommended for future research.

It is noteworthy that this study does not suggest that the blockchain technology can tackle all the issues of today's energy system, but rather it facilitates and enhances a more meaningful archetypical design for the energy industry in the digital era.

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