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Servitization of Energy Sector: Emerging Service Business Models and Startup's Participation

Mahendra Singh *, Jiao Jiao, Marian Klobasa and Rainer Frietsch

Fraunhofer Institute for Systems and Innovation Research ISI, Breslauer Str. 48, 76139 Karlsruhe, Germany
jiao.jiao@isi.fraunhofer.de (J.J.); marian.klobasa@isi.fraunhofer.de (M.K.); rainer.frietsch@isi.fraunhofer.de (R.F.)
* Correspondence: mahendra.singh@isi.fraunhofer.de

Abstract: Changing asset ownership models in the energy sector is spurring established companies and startups to implement customer-centric smart services. In this sense, startups are pioneers of innovative business models, and unbundle the energy value chain to provide various services to final customers. Although service business models have received large attention in the energy sector, the role of startups in service business model innovation (S-BMI) is not fully understood in the literature. To put this into perspective, the proposed work analyzes the six most practiced energy service categories, specifically, Comfort and Heating, Flexibility and Trading, Energy Efficiency and Management, Solar and Microgrid, Charging and Battery, and Energy Software Solutions are taken into account, accompanying service business model archetypes in the energy sector. Data from two different company databases are combined, and a list of 432 startups dealing with energy services are analyzed. The operating revenue, stakeholders, investors, and funding are considered as the main indicators to compare the service categories. The top two categories in terms of the number of startups are Solar and Microgrid (38.1%) alongside Energy Efficiency and Management (20.1%). The analysis suggests that X-as-a-service (XaaS) and platform-based business models are becoming the center-of-attention for investors and shareholders. Digital marketplaces are also evolving in the energy sector. In fact, the current study found that startups associated with XaaS, platforms, and marketplace activities are attracting the majority of investors and funding programs. From a theoretical point of view, the study has provided the main motivations and enablers behind the energy sector servitization. The findings could serve as an initial methodological framework to analyze services in the energy sector, putting service business models and startups into focus.

Keywords: service business models; startups; value chain disintegration; digitalization; servitization; XaaS; end-customer; platforms; marketplace; energy services

Citation: Singh, M.; Jiao, J.; Klobasa, M.; Frietsch, R. Servitization of Energy Sector: Emerging Service Business Models and Startup's Participation. *Energies* **2022**, *15*, 2705. https://doi.org/10.3390/en15072705

Academic Editor: Krushna Mahapatra

Received: 1 March 2022
Accepted: 30 March 2022
Published: 6 April 2022

1. Introduction

Globally, the energy sector is experiencing a fundamental transformation because of emerging digital technologies (DTs) and distributed sources of energy generation. Liberalization of the energy sector paved the way for customers as well as small and medium-sized enterprises (SMEs) and startups to participate actively in the ongoing energy-transition. Consumers are turning into prosumers, producing on-site renewable energy and offering demand flexibility to the grid. Energy storage (in combination with virtual power plants, VPP) and self-consumption are projecting end-customers as strong contenders against the century-established utility business model. Until years ago, long-established business models in the energy sector were dominated by utilities in conjunction with intermediary services like generation, transmission, distribution, and system maintenance. The interface between end-customers and energy providers is usually defined by a long-term power purchase agreement (PPA). Simply, customers have been considered buyers of electricity as a commodity against a certain tariff. Nevertheless, these conventional business models are no longer able to convince end-customers to buy electricity from utilities. At the same time, utilities are also experiencing a threat from the rising customer awareness regarding source transparency, renewable ownership, and demand for smart services. To date, a considerable amount of literature has already criticized utilities for their reluctant behavior toward customer participation and underestimating renewable potential in utility business models [1]. DTs are an underlying factor for servitization in the energy sector [2]. Technologies like the Internet of things (IoT), connected sensors, low-code platforms and digital-twin are facilitating businesses to monetize the value of data with the help of data-driven services or platforms [3,4]. Artificial intelligence (AI) and the cloud are removing barriers to billing [5], platform hosting, analytic, and real-time data access. Blockchain or distributed ledger technology (DTL) is another promising digital technology that has enabled peer-to-peer trading and a digital marketplace for energy [6].

On the policy side, energy policies underway are opening a customer-centric service-oriented energy market to deliver transparent engagement [7], where active customers [8] get multiple options to choose between the range of energy services and providers. In fact, customer-centric smart services are strongly encouraged in the common European Union scheme for rating the smart readiness of buildings [9]. On reflection, customer-centric business models appear as a milestone disrupting the energy sector and enabling customer participation in the value chain (VC). Alongside digital products, the demand for sophisticated new energy services is increasing. Ipso facto, such demands are creating a new battlefield for startups, SMEs, and established companies to come up with new smart digital energy services.

Before discussing the services in the energy sector, in the present work we have defined the servitization concept as: "The transformational process whereby a company shifts (or offer a completely new service) from a product to a service-centric business model and logic by employing service business model innovation (S-BMI)" [10]. However, in energy-service literature, services are defined as a function, which performs using energy which are means to obtain or facilitate desired end-state and services [11].

Undoubtedly, startups are leading the way to a servitized digital business model by offering tailor-made services in the energy sector. Startup operating service business models are putting high emphasis on earning customer loyalty. That also brings new shareholders and investors on board and improvises the startup's overall performance. Oftentimes, energy startups struggle to attract private investors because of fluid regulation and unclear estimation of customer base. A majority of young startups rely on public funding, green incentives, and limited support from established companies. In this context, digital technologies are allowing relatively easy modeling of the customer base, exploiting advanced transaction mechanisms such as pay-for-performance, pay-per-use, rental and leasing fee, etc. Indeed, a range of publications have examined the importance of service-based models in the energy sector [11,12]. Particularly, in [13], the authors investigated Energy-as-a-Service (EaaS) as being the most preferred emerging business model among utilities. However, the role of startups actually offering such services is underrepresented in the energy-service literature. Therefore, it goes further to examine the characteristics of startups offering service-oriented business models in the energy sector. Taking into account the discussion above, we have designed our research questions as follows:

- Value capture: What role do energy startups play in service business model innovations and how do energy services capture value by disintegrating the value chain in the energy sector?
- Service motivation: What kind of service business model innovations do energy startups bring? Which factors are encouraging energy companies to develop and use service-based business models?
- Success factors: How to measure the success of service-based business models (financial performance, funding and investment indicators for startups practicing service business models)?

To answer the above questions, the proposed research methodology is based on theoretical as well as evidence-based (data-driven) arguments. Theoretical investigation reveals the current service business model practices, use cases, servitization motivation, and enablers of innovative energy services. Further, data-driven analysis has developed a deep insight into startups actually practicing the energy service business model. The analysis elaborates on their financial performance, stakeholder involvement, and innovation aspects. The contribution of the present work is twofold:

- First, it provides a comprehensive overview of the business models of incipient services active in the energy sector. It also provides an analysis of the motivation and enablers for energy services.
- Second, the proposed methodology analyzes and compares various service business models by putting startups at the focal point of discussion.

The paper is structured to first present a succinct review of the available literature and to summarize the research questions. In Section 4, we have provided the background information of different innovative service-based business models in the energy sector. Furthermore, Section 5 describes the methodology and data sources. The key findings are discussed in Section 6 followed by discussion and conclusions in Sections 7 and 8, respectively.

2. State of Research and Motivation

Servitization is a well-addressed topic in the academic literature [14]. A number of publications have reviewed the coverage of the topic, taking into account specific industries. Industries like manufacturing, software, retail, and entertainment industries are the early users of service business models. However, the inception of the customer-centric servitization concept could be considered after the introduction of the theory '*age of customer capitalization*' [15]. Since it was reported in 2010, many efforts have been made to further develop customer-centric business models [16]. In light of recent developments, contemporary theories developing customer-based corporate valuation (CBCV) have given a strong push to service-based business models [17].

In addition to the above, changing a company's accounting and customer acquisition models attracts investors to invest in service business models. In recent literature, services are often defined as X-as-a-service (XaaS). Where the exchangeable part X could be anything, or everything-as-a-service [18]. Throughout this paper, the term 'X' will refer to the different services.

Over the course of years, the notion of servitization is becoming prominent in the energy sector [19,20]. The link between energy and services has been discussed in multiple recent studies. In [11], the authors identified 176 services under seven major categories, which are heating (space and water), cooling, cooking, refrigeration, lighting, mobility, and others. In some cases, the variation between the final value propositions is very limited and intangible to the end-customer. Few other publications have addressed the unfolding of service business models in the energy sector. For example, in [12], the authors provided an outline of smart services evolving in the energy sector. This work analyzed 175 companies, including startups, utilities, and established firms. The authors find eight types of smart energy business model archetypes comprising a mix of service and product–service business models. Furthermore, nine categories of service business models have been identified in the German energy sector [21]. In a continuous effort, analytical research done in [22] shows 57.5% (out of 2110 respondents) had a positive attitude towards smart services and third party control of data and connected devices. Furthermore, in [23] the authors investigated the impact of networked stakeholders in SBMs. In fact, servitization, circular economy, and digitalization have been identified as key trends in designing a sustainable business model [24]. XaaS services have been implemented to target the customers who value services on top of energy supply. In the energy sector, these services are initially introduced as energy efficiency services companies (ESCOs) to offer energy savings and a reduction in operational cost.

Despite the fact, the servitization of the energy sector has got wide attention among the researchers. At the same time, the role of startup companies implementing such models, and the wider impact of service business models, are not yet discussed in the literature. Considering the state-of-the-art and research development in this direction, the overarching objective of this work is to analyze various service business models by putting servitization and startups in the central point of discussion. Additionally, a methodology to access energy service startups using potentially available databases is also an underlying contribution of this work.

3. Value Chain Disintegration in Energy Sector

As previously mentioned, traditional business models in the energy sector are vertically integrated and monopolized by multiple intermediary actors. These actors are primarily concentrating on their area of expertise with less room for business model innovation. For instance, power generation companies guarantee a secure and sufficient generation of electricity. Whereas, distribution and transmission companies provide an infrastructure to maintain the security of supply. Due to the regulated energy market, the distribution and transmission companies have a natural monopoly. Therefore, it is very difficult for new entrants (particularly startups and SMEs) to enter into the value chain.

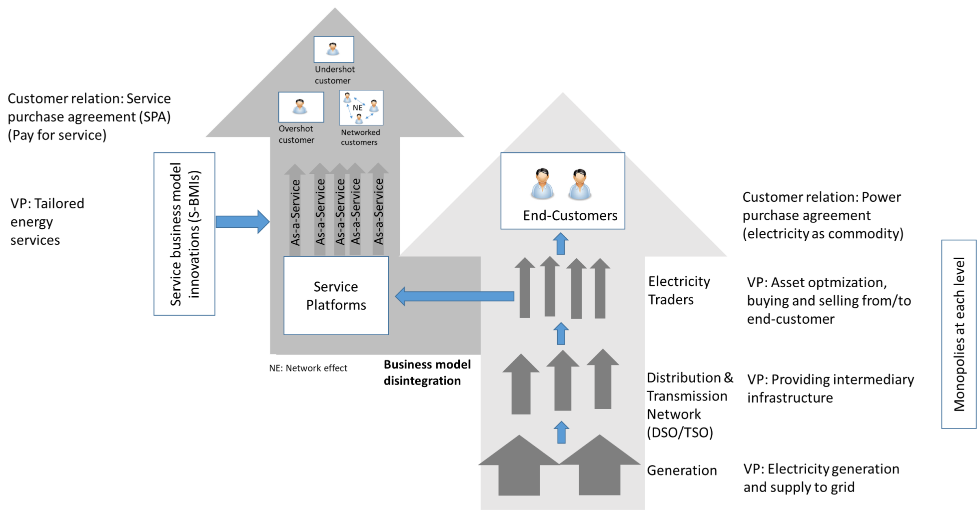


Figure 1. Disintegration of the value chain, (VP = Value proposition, NE = Network effect).

The level of competition with established actors is extremely high for new entrants at the bottom of the vertically integrated business model. However, the top end of the value chain is represented by different types of customers differentiated in terms of behavior, spending capacity, and service preferences. Indeed, the customer end of the value chain is more fragile and open in the sense of new service-related business model innovation. As illustrated in Figure 1, startups acting in close proximity to end-customers are capable of disintegrating the business model at the top end. New actors with innovative approaches to meet service demand and energy supply are entering and disrupting the market [25,26]. After analyzing the current active service business models in the energy sector, we have identified the following categories of customers:

- Undershot customers: Customers who are not satisfied with the existing energy-related services and can afford to pay for either new or improved services [27]. The limited features of existing services is the main pain point for undershoot customers. Customers use their services, but with a great expectation of future improvements. A classic example of this is when customers continue to use conventional heating or cooling systems, but are willing to pay for remotely programmable services for better control over their desired comfort level.
- Overshot customers: A group of customers who find the current services are not useful and prefer to pay for certain features of service [28]. For instance, customers might not be interested in having smart home services but prefer to use services related to indoor

thermal comfort management (e.g., heating and comfort-as-a-service). The premium for services encourages such customers to look for customized and inexpensive service solutions. Overshot customers allow a low-end disruption of the value chain.

- Network customers: Customers are connected through a network effect (NE) and enjoy positive network externality (P-NE) of certain services. The value of the network increases in proportion to the number of users. As an example, EV users using charging-as-a-service benefit from the charging network offered by the charging infrastructure owner [29,30].

There is a clear gap between technological advancement and business model practices. Startups and young entrepreneurs address such gaps by implementing business model innovation (BMI). De facto, service-driven business models belong to the category of BMI in which businesses implement services to address a specific group of customers. The above-stated customer groups are encouraging startups to innovate new, improved or connected energy services. Beyond this, service models are able to attract venture capitalists (VCs), business angels, and public funding because of their strong expected customer base, fast scalability, and potential to disrupt the value chain leading to additional profit margins. The next section highlights the various motivations and enablers of a service business model in the energy sector.

4. Motivation and Enablers for Servitization

Motivations for companies to bundle services and products vary between the industry operation, product offering, and complexity of final products. Competitive advantage, customer demand, and economic gains are observed as three prime motivations for companies to implement service business models in the manufacturing sector [31].

Whereas, the servitization narratives in the energy industry are different compared to other industries. The majority of service-driven business model innovations are put into effect by the startups to position themselves in the energy utility value chain. The servitization of the energy sector is led by the increasing new type of customers, demand for inexpensive energy services with a changing mindset for owning a product rather than valuing the final outcome of energy-related services. Economic motivations such as scalability, new revenue streams [32], lower cash burn rate, and fast return on investment are also favorable grounds for energy startups operating in the service domain. Changing the method of customer interaction, new payment models with lower transaction costs are other important motivations to set up a service business model (see Figure 2) .

In addition to the mentioned motivations, we foresee digitalization and sustainability as strong enablers of service business models in the energy sector. Nowadays, startups are enriched with customer data. The data sharing platforms and multisided digital platforms give formal reasons for service companies to build data-driven digital services. Unbeknownst to many circular economy initiatives, environmental measures are directing businesses to optimize the use of limited resources by achieving long-term sustainability goals. The next subsection looks into the details of various energy service business models.

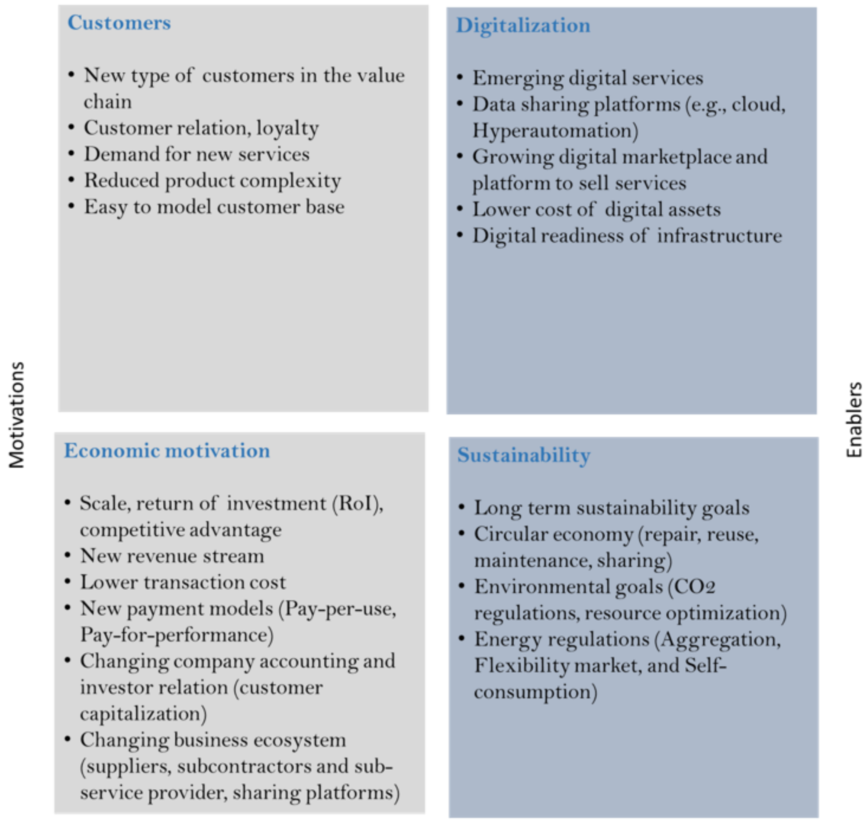


Figure 2. Service business model motivations and enablers in energy sector.

4.1. Service Business Models in Energy Sector

An extensive range of services is available in the energy sector [33]. However, considering the active startups and financial viability of business model innovations, we have identified the following archetypal X-as-a-service models in our collected startups data—described in Table 1. This table narrates the central value proposition, stakeholders, financial viability, and use cases of each business model.

Charging-as-a-service (CaaS): Owning and maintaining a charging service is an expensive affair and brings additional responsibility for EV users. Charging-as-a-service, also known as charging point-as-a-service, provides charging infrastructure (i.e., hardware and software) together with billing, payment, and charging maps, etc. [34]. End-customer or EV users are expected to pay a subscription fee to have access to the connected charging facilities. Service providers generate their revenue by renting/leasing charging points or by a subscription fee. The key stakeholders in this business model are charging fleet developers (i.e., hardware and software providers), municipalities, retails, and businesses with parking premises. This particular business model has a positive network externality due to a high EV adaptation rate [30].

Software-as-a-Service (SaaS): SaaS is a service business model that delivers software access across the internet and cloud. The software provider hosts their IT applications and software on the cloud platform, and a large number of end-customers can use such programs over the internet. A subscription fee is required to access the software services. In the energy sector, the value propositions of SaaS services are shared between end-customers and companies using SaaS to deliver their services. For example, SaaS based services are used to engage users (i.e., feedback and recommendations) with the help of dedicated apps and customer relationship management (CRM). Companies use SaaS services to manage their billing, software hosting, and accounting. Due to the thriving cloud business [35], SaaS services in the energy sector deploy energy services on a cloud platform. Powercloud [36] is a German startup offering such services in the German energy market.

Flexibility-as-a-service (FaaS): Flexibility-as-a-service is a business model initially promoted by distribution system operators (DSOs) to address network congestion and resource optimization. As a result of digitalization and self-generation with storage systems, new market models with platforms have emerged [37]. These flexibility platforms connect consumers, aggregators, DSOs, and TSOs to trade or sell flexibility from distributed resources [25,38]. Moreover, flexibility service platforms monitor flexible consumption and, with the help of aggregator platforms, end-consumers can sell their flexible load back to the grid [39]. An example of such a platform is TikoPower, developed by the German startup called Tiko [40] founded in 2014. It helps residential and industrial users to gain additional revenue from high-flexibility potential appliances such as heat pump [41].

Table 1. XaaS services in energy sector († To avoid confusion with other service model acronyms, these acronyms are modified in this work.)

X-as-a-Service Business Model	Central Value Proposition	Key Stakeholders	Financial Viability	Use Case/Example
Charging-as-a-service (CaaS)	- Networked charging stations - Charging infrastructure management - Increased property value	- EV users - EV manufacturers - Retailers, municipalities, businesses, companies with parking lots	- Subscription fee for charging point	Me energy GmbH, https://meenergy.earth/ (accessed on: 3 December 2021) (DE)
Software-as-a-service (SaaS)	- IT resource optimization - Cloud-based energy management - Data analytics, visualization and reporting	- Energy service companies (ESCOs) - Utilities - ITC technology provider - Commercial and industrial sites	- Subscription fee for software and cloud services	Wattics, https://www.wattics.com/analytics/ (accessed on: 3 December 2021) (IE)
Flexibility-as-a-service (FaaS)	- Demand-response marketplace - Load management - Saving based incentives	- ESCOs - Demand response aggregator, Retailers - Industries - Households, Commercial buildings and business owner - Energy consumers in general - Utilities	- Revenue from selling energy flexibility provision	Bamboo Energy, https://bambooenergy.tech/en/ (accessed on: 10 December 2021) (ES)
Energy-as-a-service (EaaS)	- Monitoring and load management services - Demand response - Design, installation, maintenance and performance management of energy services	- IT technology provider - Local energy market players - Commercial and industrial buildings owners - ESCOs - Utilities	- Revenue from energy saving, optimization, and energy efficient solution	Eenergy Group, https://eenergyplc.com/ (accessed on: 10 November 2021) (UK)
Solar-as-a-service (SoaaS)†	- Energy cost hedging - Green electricity - Co-financing for solar projects - One shop package for installation, maintenance, operation, management and billing	- Residential, Commercial building owner and users - Energy service companies - Energy retailers	- Subscription or leasing fee for solar assets	Ecoligo GmbH, https://ecoligo.com/ (accessed on: 13 November 2021) (DE)
Comfort-as-a-service (CoaaS)†	- Living space management - Improved indoor environmental quality (IEQ)	- Real state owner - Facility manager - Energy service companies - Building users	- Subscription fee for indoor comfort management	Evoconfort, https://www.evoconfort.com/ (accessed on: 15 November 2021) (EL)
Battery-as-a-service (BaaS)	- Battery on cloud - Battery swapping/upgrading - Battery asset management - Quickly exchangeable battery system - Universal storage	- Cloud services - EV users - Charging infrastructure developer - Battery manufacturers	- Revenue from battery swapping - Subscription fee for battery charging	Clean energy global GmbH, https://www.clean-energy-global.com/de/ (accessed on: 15 October 2021) (DE)

Table 1. *Cont.*

X-as-a-Service Business Model	Central Value Proposition	Key Stakeholders	Financial Viability	Use Case/Example
Microgrid-as-a-service (MaaS)	- Microgrid deployment financing - Operation and maintenance agreements for energy infrastructure - Integrated energy system	- Utilities, Retailers - End-consumers, Prosumers	- Revenue from customized grid solutions	Ferntech GmbH, https://ferntech.io/ (accessed on: 15 October 2021) (DE)
Trading-as-a-service (Peer-2-peer) (TaaS)	- Digital marketplace to connect consumers with energy producers - Price comparison - Direct transactions between peers - Energy trading in a network	- Utilities, Retailers - Households and commercial building owners - Business owners - Energy Communities	- Subscription fee for trading platform	Energy web foundation, https://www.energyweb.org/ (accessed on: 20-11-2021) (DE)
Heating-as-a-service (HaaS)	- Indoor thermal comfort - Remote control and monitoring - Heat pump renting - Cost saving (independent to energy price variation)	- Energy suppliers - Households and commercial building owners - Heating infrastructure developer	- Leasing or renting fee for heating system	Thermondo, (Acquired by Brookfield), https://www.thermondo.de/ (accessed on: 20-11-2021) (DE)

Energy-as-a-Service (EaaS): Energy-as-a-service is the most exercised business model in the energy sector [42]. The EaaS model is widely accepted among the ESCOs services where service providers install and manage all energy-related appliances, sensors, and energy management platforms to deliver energy savings. ESCOs deliver energy cost savings to end-customers by ameliorating the energy efficiency of installed appliances. The end-customer needs to pay a subscription fee and sign an energy performance contract (EPC). Initially, EaaS models were limited to municipality buildings, universities, schools, hospitals, and industrial sites. In recent years, the changing customer demand for end services in the residential sectors has encouraged startups to innovate service models beyond energy and cost savings. Numerous versions of the EaaS business model have emerged in the last few years. To this end, the EaaS model has overlap with other service business models. For example, solar-as-a-service and microgrid-as-a-service both have similar value propositions as EaaS, but target different customer segments and service requests [43].

Solar-as-a-service (SoaaS): Represents a business model that provides the use of solar electricity to its end-consumers instead of selling solar/PV systems as a product [44]. Startups practicing solar-as-a-service cover installation, monitoring, maintenance, and viable financing for customers. In addition, solar service could also be integrated with home energy management systems (HEMS). Customarily, solar services are arranged via a leasing or renting contact agreement [45]. The ownership of the solar system remains with the service provider. Financing, that is, winning investor confidence and administrative complexities, are identified as the main barriers to this particular business model [46].

Comfort-as-a-service (CoaaS): Modern buildings are a complex system. They comprise various appliances, heating ventilation and cooling systems (HVAC), heat pumps, sensor networks, etc. Energy management systems (EMS), building regulations, and codes focus primarily on energy-efficient operations and the reduction of consumption (cost savings). Indoor comfort is often controlled by residents, and occupants pay energy meter bills to maintain the desired level of comfort. However, building users value ultimate comfort as a final product without taking care of maintenance, energy tariff, price variability in peak hours, etc. Comfort-as-a-service is a user-centric business model [47] in which users pay for the desired comfort level, not for the energy spent to achieve this comfort. Users hand over the control of their appliances, access to data, and predetermined selection of comfort settings (e.g., temperature, lighting level, indoor air quality) to a third-party service provider [48]. Third-party operators coordinate with energy providers or energy service companies (ESCOs) to meet the energy supply while maintaining a desired comfort requirement. Moreover, CoaaS services require a digital infrastructure, such as the cloud, IoT, sensor grids, and smart HVAC systems, to realize the full potential of the business model [49].

Battery-as-a-service (BaaS): Batteries are the most expensive component of electric vehicles. Changing batteries is an extra burden for the EV owner. Battery-as-a-service is an innovative service business model that decouples batteries from the EVs and couples transport and the energy sector, allowing more flexibility for battery swapping, upgrading, or second life use [50]. BaaS also eliminates the risk of battery ownership and offers third-party maintenance services. The BaaS model is claimed to be a circular business model that maximizes asset utilization and reduces the environmental footprint of battery materials. The potential proliferation of the BaaS model is not only limited to the EV sector, but is also in several off-grid services where batteries or battery packs are required (e.g., construction and maintenance work). German startup Clean Energy Global GmbH provides a storage Clean Energy Pack that covers various battery services in an intelligent network. Besides startups, established companies are also establishing separate battery service business units to target EV users [51].

Microgrid-as-a-service (MaaS): Financing for microgrid projects is a crucial challenge for the microgrid project developer. To tackle this challenge, microgrid-as-a-service offers a new financing mechanism empowering organizations, communities, and individuals to deploy microgrids without any upfront investment. In addition to hardware costs, MaaS models also cover the networking, monitoring, and maintenance of microgrids. End-customers do not have to concern themselves with the performance risk and return of the investment. Akin to other service models in the energy sector, asset ownership remains with the service provider, and the end-customer benefits from a running microgrid. In remote areas, microgrids with distributed solar/PV or co-generation result in less costly electricity than that from the main grid. In other cases, the savings are spent on electrical or resilience upgrades. A number of microgrid vendors are already practicing this business model while developing open architectures and software services to network microgrids with renewable and storage systems [52].

Trading-as-a-service (Peer-2-Peer) (TaaS, P2P): P2P is an electricity model in which prosumers or self-consumers can trade electricity within their local community and neighborhood. Prosumers are also able to establish an energy community and participate in a local energy market [53]. Distributed ledger technology (Blockchain) is used to make a reliable and secure payment transaction. P2P services are enablers of the platform ecosystem in the energy sector [54], where consumers and traders can participate in a common marketplace to sell their energy flexibility. To take advantage of P2P trading, blockchain technology and growing distributed energy sources, a number of startups have already developed commercial trading or a trading-as-a-service platform (sonnenCommunity [55] in Germany and Vandebron [56] in the Netherlands). Such platforms have built-in intelligence to match and recommend a peer based on their energy demand and market price. In return, users need to pay a trading or subscription fee to trade with their peers.

Heating-as-a-Service (HaaS): Decarbonizing the heating sector is a far-reaching goal among the EU member states [57]. Orchestrating smart-home devices, connected heat pumps, and digital heating infrastructure (e.g., sensors, smart thermostats) are the key drivers of the heating-as-a-service business model. In this business model, innovation service companies offer a heat contract that includes thermal comfort in individual building zones, hot water, and remote control of heating appliances. Dwellers are expected to pay for their heat plan rather than Kilowatt-hours (kWh) [58]. Studies and pilots have shown an improved consumer experience for HaaS business and consumers are willing to pay for their desired heating plan [59]. Nevertheless, data privacy, interoperability between heating systems and asset ownership (consume vs. supply) are identified as the main barriers in the HaaS model. Moreover, it also requires clear policy and guidelines to connect HaaS to the building retrofit [60].

Besides the XaaS services mentioned above, several other services are also active in the energy sector. A few examples are lighting-as-a-service [61] and reliability-as-a-service [62] implemented by Signify Philips and Engie Derms, respectively. However, there are no such use cases in the context of energy startups.

It is also noticed that a variety of business models have minor variations in their final value proposition. As an example, flexibility or trading-as-a-service business models mainly offer a digital marketplace to end-customers to sell or trade their energy flexibility. On a similar note, the comfort and HaaS business models aim for temperature set-point adjustment as a unique selling point. After making an assessment of energy services and their value propositions to end-customers, six primary categories are considered for further analysis and discussed in the following section.

5. Data and Methodology

5.1. Data

The detailed steps of data collection and methodology are shown in Figure 3. Initial startup data were collected during the project called Innovation Systems Data-Excellence Center (ISDEC) [63].

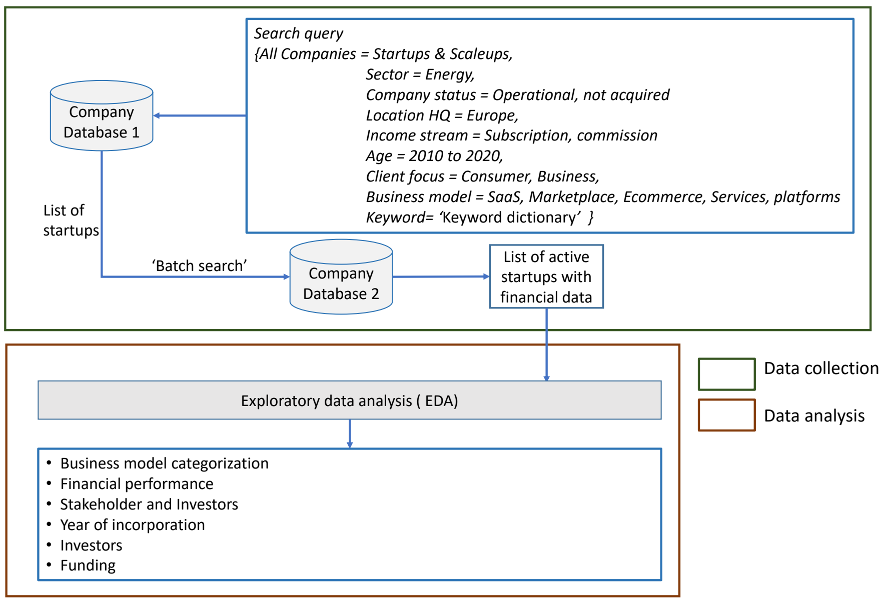


Figure 3. Data collection and methodology.

The aim of the project was to collect various activities of innovative startups active in the German energy sector. Data were collected from different sources comprising company databases, professional data collection companies, and web-scraping. A detailed data collection methodology and analysis is published in [21]. Moreover, the central focus was given to the use of digital technologies along with business model practices. Interestingly, a significant number of startups have appeared with platform- and service-driven business models [64]. Previously, data collection was limited to German startups.

To expand geographical coverage and recognize service startups, we have updated our data collection and analysis methodology. The scope of the collected dataset is EU27 along with UK and Norway. Two databases are combined to access the complete details of startups dealing with service business models. Database 1 is known as Dealroom. Dealroom is a global data platform for intelligence on innovative startups, and collects startups from all economically developed countries [65]. The data quality for European countries is high, the data are well organized and complete in the sense of business model practices. However, Dealroom has certain limitations in the providing financial data of companies. To overcome this issue, Database 2, i.e., the Amadeus database is used. It contains economic data on more than 25 million public and private companies (including startups) from 45 EU countries. The combination of the above two databases makes data collection complete in terms of business model search, financial performance, and background information such as funding, year of incorporation, stakeholder details, etc.

5.2. Methodology

As previously stated, based on our initial investigation on service business models (Section 4.1) in the energy sector, we define six main categories, namely: Comfort and Heating, Flexibility and Trading, Energy Efficiency and Management, Solar and Microgrid, Charging and Battery, Energy Software solutions. A search query is designed to fetch the startups offering energy-related service models in the energy sector (see Figure 3).

Dealroom offers a structured search query by merging various parameters together. Furthermore, a keyword dictionary helps to identify domain-specific startups. For instance, startups providing charging services are searched by adding keywords *Charging*, *Charging infrastructure*, *Charging hardware & software*, *EV charging*, etc. In a similar vein, startups belonging to other categories are searched by adding keyword tags to the keyword dictionary in the search query. Table 2 shows the service categories and corresponding search keywords—a total of 48 keyword tags are used to identify energy service startups in the given categories. In the second step of data collection, the individual company's web/LinkedIn pages and Crunchbase company profiles are also visited to validate the startup's activities. In the next step, a list of startups is provided to Database 2. The Amadeus database supports batch searching to search a list of companies. Users can select fields like company name and country origin to avoid companies with similar names incorporated in other EU countries.

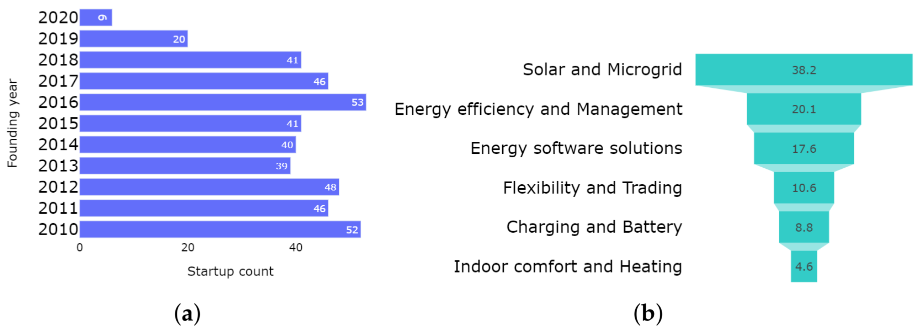


Figure 4. Startups distribution by (**a**) Founding year (**b**) Category (in percentage).

The resulting search list was integrated into the available company names in the database. The outcome of database 2 is a list of startups compiled with financial performance. A total of 432 startups have appeared with the designed search query. Moreover, 38.2% startups belong to the category Solar and Microgrid, followed by Energy Efficiency and Management at 20.1% startups (see Figure 4b). Figure 4a illustrates the number of startups founded in the period between 2010 to 2020.

An exploratory data analysis (EDA) is performed to analyze and compare the startups in service business model categories. EDA analysis helps to summarize the main characteristics of the data without doing any formal modeling. Comparing variables by employing visualization techniques makes it easier to investigate patterns, causal relationships, and the validity of assumptions. In this study, univariate and multivariate EDA analysis are used for in-depth exploration of data variables.

Table 2. Energy startup's core category and service focus.

Service Category	Screening Keywords	
Comfort and Heating	- Heating services - Indoor comfort - District heating - Thermal comfort	- Heating network - Indoor temperature - Heating-as-a-Service - Comfort-as-a-Service
Flexibility and Trading	- Flexibility services, - Balancing services - Load management - Load curtailment - Energy Communities - Flexibility-as-a-Service	- Virtual power plant (VPP) - Electricity trading - Trading-as-a-Service - Demand–response - Demand aggregation services
Energy Efficiency and Management	- Energy management - Intelligent monitoring and control technologies - Energy efficiency - Energy services	- Smart home energy management - Efficiency-as-a-Service - Energy-as-a-Service
Solar and Microgrid	- Solar services - Solar financing - Solar-as-a-Service - Solar/PV installation	- Microgrid installation and operation services - Microgrid-as-a-Service
Charging and Battery	- Charging infrastructure - EV charging - Smart charging - Charging point - Charging-as-a-Service	- Charging service - Charging subscription - Battery swapping - Charging hardware & software - Battery services - Battery-as-a-Service
Energy Software Solutions	- Cloud platforms - Energy Software services - Software platforms	- Energy cloud - Cloud or Software-as-a-Service (SaaS)

6. Results

This section deciphers the main findings of exploratory data analysis. Firstly, Figure 5 depicts the number of startups registered in different EU countries.

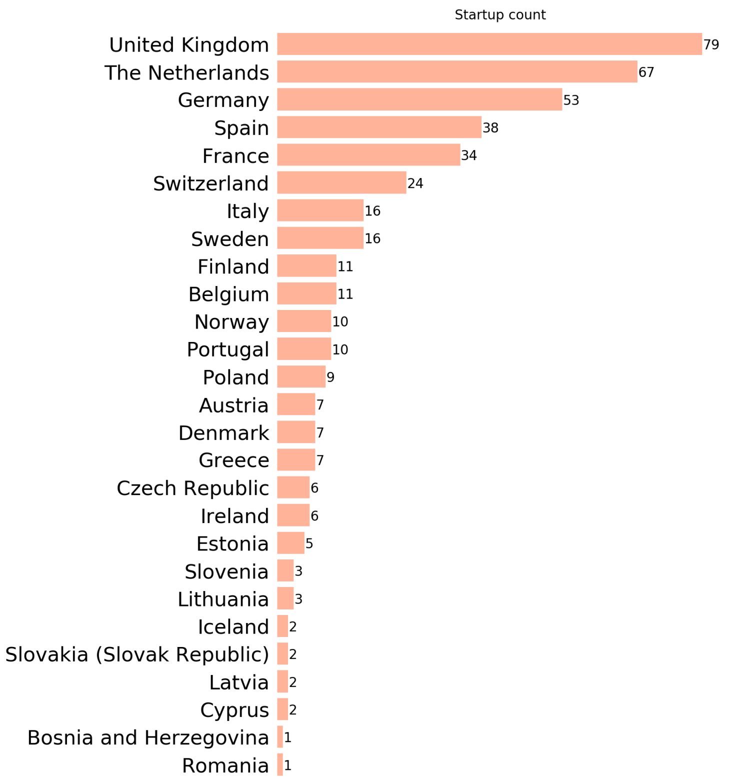


Figure 5. Founding countries (Head quarter), period 2010–2020.

The United Kingdom, The Netherlands, Germany, Spain, and France are the top five countries where startups have located their head office. Scandinavian countries (Sweden, Norway, Finland, and Denmark) also have a significant contribution (10.3%). Eastern European and Balkan countries have a relatively smaller share of startups.

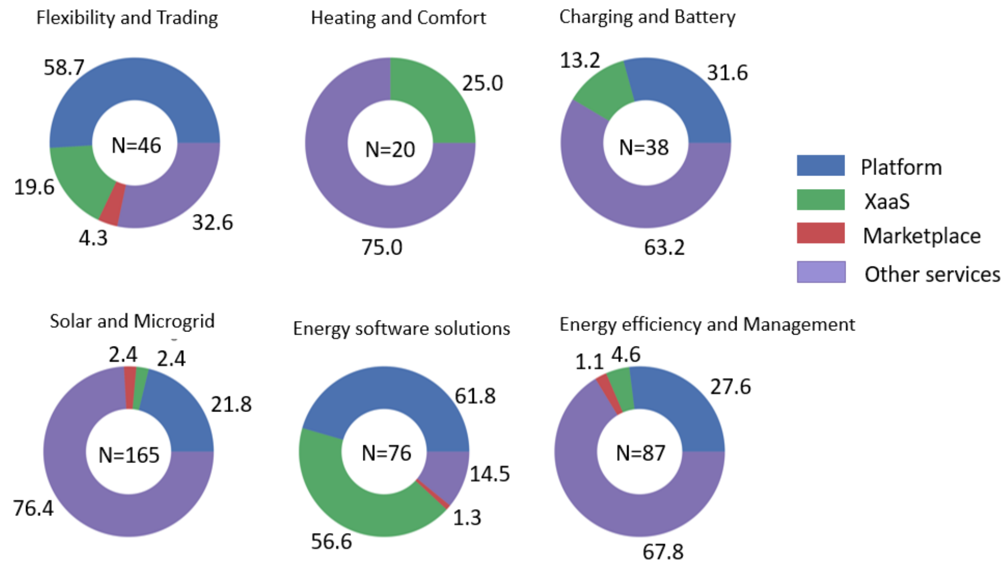


Figure 6. Distribution of platforms, XaaS, marketplace, and other services in energy service categories in percentage (N = Number of startups).

As mentioned previously, a large number of startups have developed digital platforms, XaaS, and marketplaces to offer energy-related services. Platforms are often defined as a multi-sided collaborative space where multiple actors meet to create value by participating in various activities such as energy supply, transaction, trading, and energy management. Whereas, the online energy marketplace offers a space for purchasing products, service comparison, and financing gateways for end-customers. In some instances, these marketplaces are owned by startups and supported by utilities.

Startups offering Energy Software solutions have reported the largest share of platforms (61.8%) and XaaS (56.6%) business models. Likewise, 58.7% of startups in the Flexibility and Trading category have promoted platforms for energy flexibility and trading services. Moreover, startups developing both XaaS and platform-based services have been counted separately, but are not mutually exclusive. As shown in Figure 6, platform business models have emerged in all categories, with the exception of startups belonging to the Comfort and Eating category. XaaS and marketplaces are other important channels for energy service companies. It is interesting to note that XaaS has appeared in all six categories in this study. Concurrently, marketplaces are also popping up in Europe with increased customer engagement. A total od 2.4% of companies practicing solar and microgrid services have already implemented a marketplace for their service portfolio. Moreover, the share of startups exercising marketplace-driven business models is very limited at present, and is expected to grow over time.

6.1. Financial Performance: Operating Revenue

Operating revenue refers to the value of services delivered to the customer during a given period. Hence, we looked at the operating revenue of each service category. The Amadeus database provides all indispensable financial details of companies. In some cases, these details are not available for relatively new or less financially active companies. Figure 7 shows the operating revenue (last available financial year) of all categories.

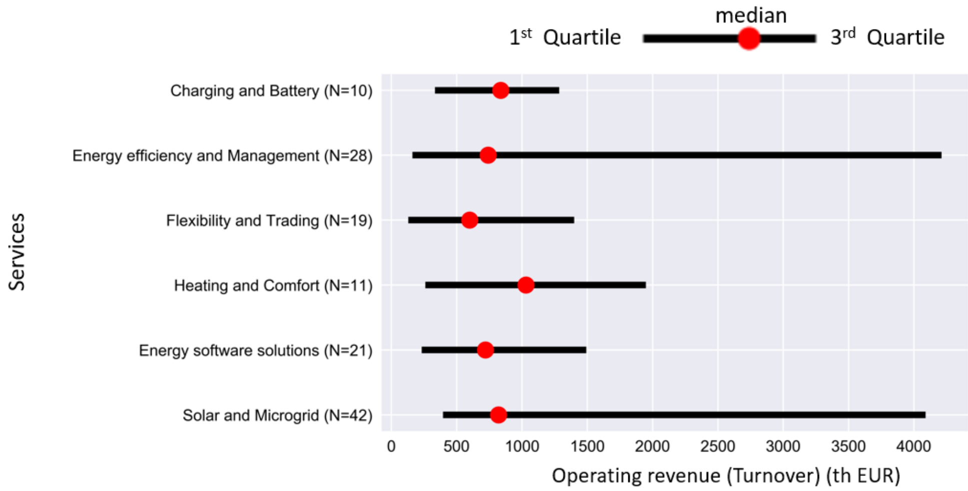


Figure 7. Operating revenue of startups in different service categories (N = number of startups).

It is interesting to note that a small number of startups in the Heating and Comfort category have reported financial performance in the database but with a higher median value. The rest of the categories have median values between the range of Euro 500 to 1000 K.

From Figure 7 it is clear that the 3^{rd} quartile is farther away from the median value for the categories of Energy Efficiency and Solar Services. It implies there is a greater distribution among the larger values and higher interquartile range (IQR) (Equation (1)).

$$IQR = 3^{rd} quartile - 1^{st} quartile \tag{1}$$

This interpretation leads to the conclusion that startups that belong to these categories have larger operating revenue portfolios. Some notable examples of startups belonging to these two categories are the Danish company Makeen Energy and Vlaams Energiebedrijf from Belgium.

6.2. Shareholder Fund Analysis

Table 3 explains the important statistical variables of shareholder's funds. Similar to the previous result, the shareholder's details are not available for all startups in the company database.

Table 3. Shareholder's funds (th EUR).

Service Category	No. of Companies	Average	Standard Deviation	Median	Upper Limit
Solar and Microgrid	84	4978	21,166	190	168,118
Heating and Comfort	14	439	1874	23	6849
Energy Software solutions	49	519	1581	70	9899
Flexibility and Trading	29	2769	8428	108	43,572
Charging and Battery	25	1767	6183	75	30,415
Energy efficiency and Management	49	1817	9316	105	44,365

A total of 84 startups are spotted in the Solar and Microgrid category with a higher average (Euro 4978 K) and median (Euro 190 K) value. Due to the limitations of data availability, an equal number of startups with shareholder details are present in the categories; Energy Software Solutions and Energy Efficiency and Management. However, startups in the category of Energy Efficiency and management have a significantly higher standard deviation (SD) and level of average shareholder funds. Notwithstanding, startups in Flexibility and Trading come up with a higher average and SD in comparison to all other categories except Solar and Microgrid, Energy Efficiency and Management. The upper limit of shareholder funds is the maximum for Solar and Microgrid startups, followed by the Energy Efficiency and Management category.

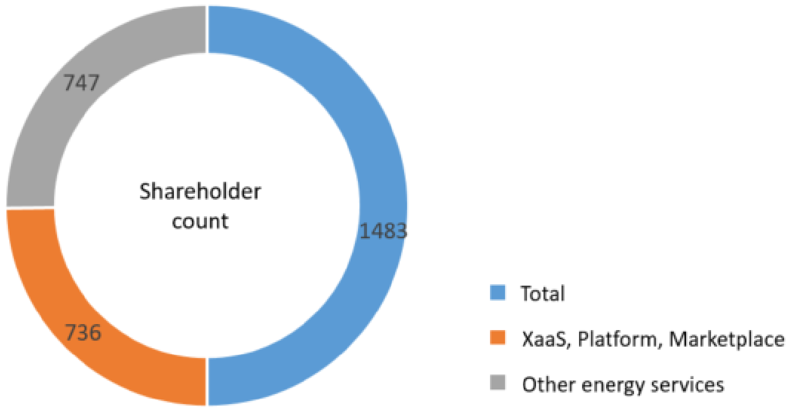


Figure 8. Shareholders count supporting platform, XaaS, marketplace and other energy services.

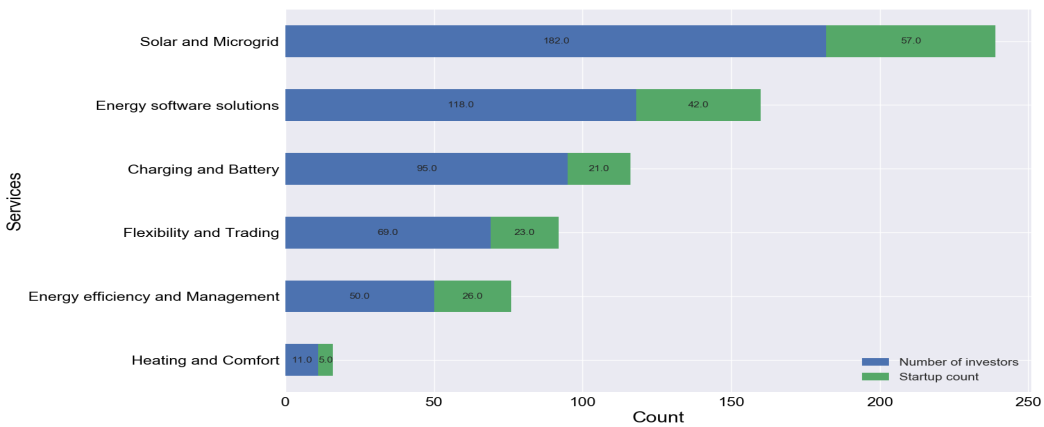
The present work has identified 1483 shareholders in all six categories of energy startup. As illustrated in Figure 8, approximately 49.6% of them own startups engaged in the activities of XaaS, platforms, and marketplace.

6.3. Funding and Investors Analysis

Funding and investment are the indicators of an investor's interest in a particular startup.

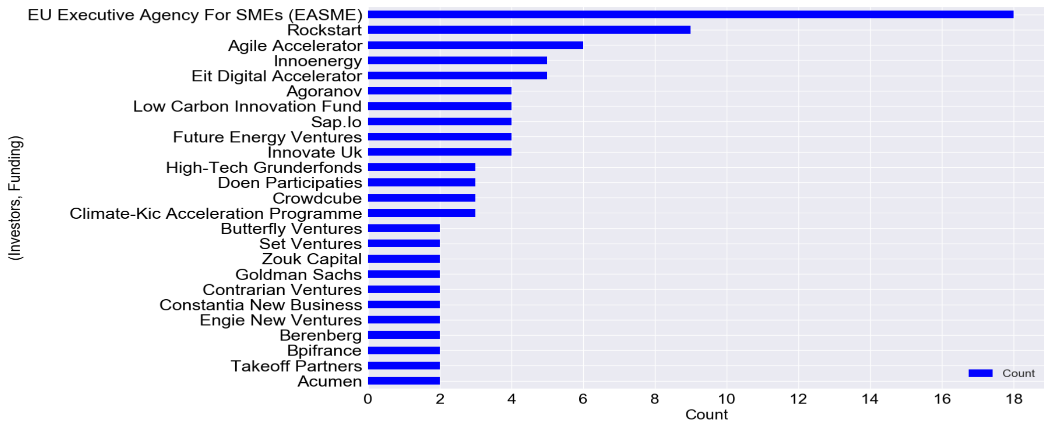
Dealroom database provides the funding and investor details for this analysis. There is a growing interest in energy platforms, marketplace, and XaaS, receiving attention from multiple well-known startup accelerators and public funding programs.

Figure 9a presents the investor count for startups realizing the platform, XaaS, and marketplace in each category. Clearly, the investor count for the Solar and Microgrid category is higher because of the large sum of startups in this category. In total, 18 startups have received funding support from the EU executive agency for SMEs, whereas the Netherlands-based startup accelerator, Rockstart, is at second place with nine startups. Other interesting funding programs recognized in this category are E.ON Agile accelerator, and the EU-funded Innoenergy. Moreover, SAP.io is supporting innovative high-tech startups globally and is mentioned with four startups in the collected data. Figure 9b shows the top 25 investors and funding support programs for startups that have implemented either a platform, marketplace, or XaaS business model.



(**a**)

Figure 9. *Cont.*



(**b**)

Figure 9. Inventors and funding for startups involved in Platforms, XaaS and Marketplace related services. (**a**) Investor count in different service categories (**b**) Top 25 investor and funding support.

7. Discussion

Although clean energy technologies are widely available and have clear economic benefits, there are several roadblocks that delay these technologies from being deployed. High upfront costs, perception of greater performance risk and other investment priorities are a few main challenges that need to be addressed by stakeholders and policy makers. At this point, the service business model overwhelms these challenges. It mitigates resource commoditization, enables innovation, accelerates clean energy financing, and supports resource circularity. Services have become an integrated part of the energy value chain. Several incumbent players in the market are disrupting the value chain and providing energy services on top of kilowatt-hours. Startups are the early adopters of service business models. The study suggests that the majority of startups are linked with services related to Solar and Microgrids. However, their platformization and XaaS services mean that startups active in energy flexibility-trading and energy software solutions are leaders. Startups are leveraging blockchain technology to establish service marketplaces.

The analysis has shown an interesting trend of startups setting up such service marketplaces (see Figure 6). Undeniably, additional effort is required to bring service marketplaces and platform ecosystems to the center of the customer-centric energy market. On the basis of the data presented in this work, it can be inferred that the majority of startups are in transition to adopt new service business models and digital platforms rather than offering conventional energy services.

From the consumer point of view, the participation of consumers in such services is still limited, and requires a comprehensive service agreement management framework to realize the full benefit of these energy services. Therefore, it becomes necessary to increase the comprehensiveness of the potential services to be implemented. Furthermore, the energy service provider must utilize new sources of data, such as smart-meters, homes, connected heat pumps, and appliances to ameliorate their service offerings.

The existing services should aim to bind key stakeholders involved in delivering final services to end-consumers to guarantee the availability, quality, and resilience of energy services. Services include multiple vendors and suppliers to execute the end user's service request. Each service vendor must takes responsibility for their component's availability. For example, heating services require a well-functioning role of energy suppliers, infrastructure developers, digital payment, and maintenance services. The increasing complexity of energy services requires an innovative and common framework for managing multiple services in the energy sector. Finally, policymakers should protect the startup's interests and place viable competitive policies for service business models, because they are easy to copy and loosely protected by patents and copyrights [66].

8. Conclusions and Future Scope

The present study was designed to determine the trends of business model servitization in the energy sector. Startups are playing an important role and disrupting traditional business models. The findings of this work clearly support the modernization of energy services. In practice, advanced energy services are supported by innovative payment models (e.g., pay-for services, outcomes, and performance) and digital technologies.

A large share of startups are dealing with service innovations. Customer-centric servitization definitely enables new customer base modeling, better estimation of profitability, and customer loyalty. Moving from product to digital services also gets investors' attention because of the relatively easy assessment and validation of existing and potential markets. Knowing the importance of services in the energy sector, the present work has explored all major service business models and sheds light on platform and marketplace services in the energy sector. With respect to the second research question, it was found that not only are economic motivations driving energy sector servitization, but also new types of customers, sustainability issues and digitalization are persuading new firms to innovate new services and business models.

Over the course of the research, a methodology has been proposed to access energy service startups. Two distinct company databases are combined to complete more general details (e.g., origin, data of incorporation, and investors), as well as financial performance, that is, operating revenue and shareholder details of individual startups. Details of 432 European startups founded between 2010 to 2020 are collected. The United Kingdom, the Netherlands, and Germany are the three leading countries in terms of the number of startups founded in the given period. Six main service categories have been determined based on the startup's business model description. Furthermore, the proposed six categories are compared. The financial performance of individual groups is measured using the variables of operating revenue and shareholder funds. Solar and Microgrid, together with Energy Efficiency and Management have shown a larger financial portfolio. In addition, funding and investor support for startups realizing XaaS, platforms, and marketplaces is also presented in this study.

The present study provides a first comprehensive assessment of startups with service business models in the energy sector. However, the generalisability of these results is subject to certain limitations. For instance, missing financial data underestimate newly founded startups. In such circumstances, other variables such as funding series, market maturation of developed services, and support from established energy companies should be taken into account. From a methodological point of view, the present study relies on certain keywords to categorize the service startups. In practice, startups could offer multiple services and belong to more than one category. Setting a boundary line between the services is challenging and requires hard assumptions.

Notwithstanding these limitations, the study suggests that XaaS, platforms, and marketplace services are setting a new business model trend in the energy sector. This research has raised many questions that need further investigation. For instance, advanced text analytical methods could be used to classify startups into categories, or even into subcategories. Furthermore, the connection between energy servitization and the UN's Sustainable Development Goals (SDGs) needs to be investigated in a detailed manner. More broadly, the follow-up research will aim to determine the sustainability and resource circularity aspects of energy services.

Author Contributions: Conceptualization, M.S. and M.K.; methodology, M.S.; validation, R.F.; formal analysis, M.S.; data curation, J.J.; writing—original draft preparation, M.S.; writing—review and editing, M.K.; visualization, J.J.; supervision, R.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Fraunhofer society under the project Innovation System Data Excellence Center ISDEC). Available online: https://www.isi.fraunhofer.de/de/themen/data-science.html (accessed on: 1 February 2022).

Data Availability Statement: A sample of data is available from the corresponding authors.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
CBCV	Customer-based Corporate Valuation
DT	Digital-Twin
DTL	Distributed Ledger Technology
ESCOs	Energy efficiency service companies
EU	European Union
EDA	Exploratory Data Analysis
ICT	Information and Communication Technology
IQR	Interquartile range
IoT	Internet of Things
PPA	Power Purchase agreement
RoI	Return of Investment
S-BMI	Service Business Model Innovation
SME	Small and Medium Enterprise
VCs	Venture Capitalists
VPP	Virtual Power Plant
XaaS	X-as-a-Service

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