Distributed Peer-to-Peer Energy Trading in Virtual Microgrids: A Blockchain Survey for Future Smart Grid

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September 20, 2022

Abstract

Due to the apparent demands and constraints faced by energy systems operating in the market world, the Prosumer Energy trade strategy was selected as a potential opportunity for research and industries. Energy trading has expanded due to the availability of dispersed energy sources and power users who produce more electricity than they would otherwise and can profitably export their excess fuel. The energy trading system blends energy from various sources and effectively coordinates it to ensure stable and optimal usage of available resources and better facilities for energy users. Peer-to-peer (P2P) energy trading is a joint research topic that involves various managerial and technical challenges. This paper provides an overview of peer-to-peer energy exchange and how blockchain can be used to increase transparency and overall performance, including the degree of decentralization, scalability, and device reliability. A thorough examination of the Prosumer Smart Grid environment is explored and clarified. The energy sharing mechanism among consumers comprises two major components: information/digital technology and optimization techniques. Three blockchain-based energy sharing models have been proposed to overcome technical and market barriers to adopt this revolutionary technology. The paper further discusses open topics and possible future paths for peer-to-peer blockchain-based energy sharing.

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Funding Information: The Deanship of Scientific Research (DSR) at King Abdulaziz University (KAU), Jeddah, Saudi Arabia has funded this project under grant no. G: 109-156-1443.

Abstract: Due to the apparent demands and constraints faced by energy systems operating in the market world, the Prosumer Energy trade strategy was selected as a potential opportunity for research and industries. Energy trading has expanded due to the availability of dispersed energy sources and power users who produce more electricity than they would otherwise and can profitably export their excess fuel. The energy trading system blends energy from various sources and effectively coordinates it to ensure stable and optimal usage of available resources and better facilities for energy users. Peer-to-peer (P2P) energy trading is a joint research topic that involves various managerial and technical challenges. This paper provides an overview of peer-to-peer energy exchange and how blockchain can be used to increase transparency and overall performance, including the degree of decentralization, scalability, and device reliability. A thorough examination of the Prosumer Smart Grid environment is explored and clarified. The energy sharing mechanism among consumers comprises two major components: information/digital technology and optimization techniques. Three blockchain-based energy sharing models have been proposed to overcome technical and market barriers

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Keywords: Smart Grid; Prosumer; Peer-to-peer; Blockchain; Energy Trade

1. Introduction

Nowadays, smart grids (SGs) have been considered promising research issues because of their efficiency in addressing previous networks' devastating problems and complications. SG technologies significantly improve energy demand by involving small networks and distributed energy resources. Existing infrastructure stakeholders are attracted to the rapid growth in electricity use and transparent infrastructure [1]. SGs have also been chosen as powerful self-processing technologies that allow the transfer of electricity and innovation technologies in the same ways. Various forms of energy consumption that use resources, management, transfer and exchange with others have been created quickly and effectively [2]. This new concept of energy consumption is classified as "Prosumer". Due to the flexibility and energy conservation in the distribution phase of electricity, a great interest of customers is observed in smart grid sharing [3]. In this vein, the Prosumer will have a crucial role in emerging SGs, organizing peak periods, energy consumption, and rationalization [4]. Therefore, it is expected that Energy Management Systems (EMSs) and Internet of Things (IoT) systems will be incorporated into identifying and analyzing related problems and implementing and testing the impact of the prosumer requirements on potential SGs. These latter have prompted the Power Service Provider (PSP) to improve power lines in providing advanced technologies and applications for developing consumer relationships and responding to Prosumer requirements and the energy leasing method [5]. This approach has encouraged PSP to establish modern, scalable computing systems, decentralized structures and statistical techniques. The latter aims to efficiently manage services, engage stakeholders and promote progress in business strategy [6]. As a result, the PSP provided and secured a power line to customers rather than leasing power lines [7].

In Reference [8], the authors demonstrated that SG was also certified and chosen as a solution that includes fuels, knowledge, communications, commercial areas, and various applications to obtain scientific, economic, and legal priorities. According to digitization, convergence with SG technologies, interoperability, and new specifications has become increasingly necessary for Small-to-Medium-Enterprises (SMEs). The traditional network has evolved with innovative technology and intelligent applications. Consequently, the global energy infrastructure has become more diversified, resulting in digital communications among all stakeholders, such as industries and Prosumer [9].

The work presented in [10] identifies how most technologies should be seamlessly and independently, fully compatible with PSP and companies, with the inclusion of the IoT as a potential solution. The emerging potential solution included a wide range of technologies, including smart housing, artificial manufacturing, smart cities, advanced agriculture, the intelligence industry (also known as industries 4.0), SG, etc. It can be emphasized that the IoT has become an important pillar of SG due to its flexibility in connecting the Grid, network and applications with uniquely defined entities and the ability to share information on a system without interacting with devices or equipment or human and computer [11]. So, the specific qualifications and features of edge technologies, Prosumer and smart applications are important because they will determine in the future, classifications of applications, tools, and techniques applied within smart homes, Internet infrastructure, web and computer services, and infrastructure [12]. In Reference [13], the authors have shown that the IoT will restructure our ideas about societies worldwide. According to the International Energy Agency (IEA), attempting to create Smart Grid technology that improves and replaces existing systems is driving people and communities to smart infrastructure innovations (according to the International Energy Agency (IEA)). SG is one of the pillars of creating a stable, safer and productive economy. The latter will allow the management and resolution of all kinds of problems related to lighting, traffic lights, pollution, parking lots, street alarms, and early detection of excessive resources, emergency weather, and energy storage. Also, SG does the same with infrastructure in power lines, smart meters, consoles, post-station systems, switches, sensors, applications and more [14]. Due to the diversity of advanced technologies, SG has become less expensive than the current electricity grid. Switching to SG requires electricity from a variety of sources, which are distributed frequently [15]. The advanced development of the network will include conventional power plants, solar and wind energy sources, plug-ins, and energy storage facilities. It can significantly reduce energy consumption and costs by using and maintaining data. For example, in [16], the authors showed that smart lighting is designed and automatically tracked around different areas, where adjusted to meet daylight or traffic requirements and quickly determines energy demand. In [17], the authors have shown that consumers can adjust the home temperatures and the air conditioners, depending on customer requirements, during all periods of work or holidays. Indeed, the authors report that SG with IoT is designed to reduce costs by tracking smart energy and switching the source when power outages are detected. In [18], the authors suggested that numerous reports prove that IoT growth will promote the US energy sector to integrate an edge of renewable facilities to improve functionalities of both wind power generation, micro-grid networks and feeding structures. In [19], the authors showed that IoT-SGs would help the transportation and parking station sectors communicate and collect real-time information from drivers and authorities using advanced sensors. This vision would effectively reduce road congestion, develop traffic options, report pedestrians on street collisions, improve traffic solutions, track street collisions among pedestrians, damage the urban environment and encourage road charges and park meter automatically. Furthermore, autonomous vehicles can work wirelessly through the Internet of Things technology. The authors reported in [20] that innovative IoT technologies could ensure waste and water management and reduce emissions of greenhouse gases. It may also include monitoring of products in real-time and loss management results. In [21], the authors show that IoT technologies and big data are included to collect and monitor water movement and temperature details and help users manage energy demand, regulate energy consumption and reduce waste. To achieve these goals, timer and infrastructure are included. In [22], the authors stated that IoT would be used to supply electricity to areas with low population density by allowing the transition to integrated networks linking national or regional infrastructure. These networks are necessary to implement modern energy technologies by continuing to use the latest technologies. In [23], the authors suggested that IoT was chosen as the best solution for smart cities and SGs. Indeed, this latter will report the problems in the region in real-time. For example, in Mannheim, Germany, several SG applications were introduced and implemented using IoT. With this initiative, green resources were implemented on a large scale, and energy use was planned and developed in Mannheim cities [24]. In Mannheim cities, Schneider Electric Company offers a variety of wired solar power systems for families. This will allow the family to have PV systems, control and maintenance equipment so that the entire network is exhausted or until solar energy is produced and converted to meet household energy demand during peak periods [25].

In [26], the authors stated that the Lumin Energy Project (LEP) was chosen as an attractive and innovative project. LEP included IoT technologies, which saved costs and emissions while promoting clean energy. This project provides an efficient program for solar panels with adaptive storage units. In [27], the authors emphasized that many technologies have been discovered to facilitate the decentralization of correspondence, data storage, and delivery in recent years with all of these approximate activities. This phenomenon is strengthening research and industries to present the Edge computing model as a potential solution. Edge computing will be included in the grid for computing. This will ensure that storage and networks are linked to the database and data centers in the cloud. In [28], the authors argue that edge computing will be involved in the future to increase reaction times, reduce energy prices, increase interactions, scalability, and confidentiality. In [29], Edge Computing has been incorporated to help heterogeneous IoT systems communicate through specific network topology, different devices (sensors, cars, machines, computers, metering computers, etc.). In [30], the authors suggest that several disciplines will benefit from IoT smart grid solutions such as Business 4.0, Energy Management and Prosumers, and will support many academics and industries. The heterogeneous data collected and generated by IoT devices can be used to provide advanced computing technology solutions for infrastructure according to the three-tier computing infrastructure (IoT-Sensors, Cloud-Services and Edge Nodes) [31]. With Edge Computing, IoT platforms allow gathering information from hundreds or even thousands of data sets and helping companies determine whether or not they will work. Anticipate how cultural changes need to recognize the adoption of emerging technology. This will prompt many observers to plan the electricity grid, especially given the green hybrid electric vehicles [32]. In [33], the authors showed that SG responds to potential electricity consumption problems by combining wireless detection systems and cloud computing.

Moreover, data protection concerns raise significant issues in entering study groups while using and disseminating electrical data. To enhance the pillars of SG, a blockchain platform is included. Blockchain infrastructure will be provided with accurate strategies to oversee data exchange between customers and SGs [34].

In this review paper, we make the following contributions:

- We survey and classify the advantages of the benefits smart grid Prosumers concepts.
- We discuss Smart Grid Energy Management and Optimization algorithms
- We discuss Energy Tade/Prosumer Classifications and prosumer types and models.
- We provide a detailed survey of Prosumer Energy Management Techniques.
- Three decentralized energy exchange frameworks proposed in this paper make the infrastructure use of blockchain.
- We outline open issues, challenges, and future research directions related to Blockchain smart grid.

A list of acronyms used throughout the paper is presented in Appendix A (Table A1).

The remaining part of the survey is organized as follows: Section 1 introduces the edge computing and IoT concepts. In "Preliminaries: Detailed Analysis of the Literature" Section 2, we will provide a state of the art of essential studies that addressed various challenges and issues in Prosumer SG and energy prosumer, and Prosumer classifications. The "Peer-to-Peer Energy Trading" Section 3 discusses the peer-to-peer energy trading concept, architecture, and techniques. In "Blockchain Technology in SG" Section 4, we discuss the Blockchain architecture, the information processing in Prosumer SG, the concept, model, and the future energy management systems. In Section 5, we provide open issues and Future directions. We conclude the survey paper in Section 6.

2. Preliminaries: Detailed Analysis of the Literature

2.1 Summary of SG Prosumer/Energy Trade

This sub-section describes the overall distribution structure of the hierarchical Prosumer-Smart Grid given by Figure 1. The presented hierarchical scheme explains the relationship between appliances, intelligent applications, cloud and Edge Calculation based Prosumers. IoT applications on the edge of the network tend to produce an enormous amount of data that can be calculated in data centers, limiting access to service requirements. Additionally, edge-based devices continuously use data in the cloud to enforce Prosumer to create data centers, unify access and deliver data. Edge aims to transfer data collected from data centers to the platform's advantages using smart devices, Fifth-generation wireless (5G) or network gateways to perform tasks and provide cloud solutions.

Figure 1. Overall structure of a distribution Prosumer-smart Grid system

SGs are a set of tools for power consumption, control, software, grid technology installations deployed in homes, businesses, and the entire electric power grid. In this vein, SG innovations can be described as standalone structures that can efficiently address challenges in the electricity grid and ensure that all customers can access reliable electricity. SG will be the successor to the previous conventional networks by providing cleaner, more energy-efficient, more stable and sustainable electrical supplies [35]. Given the complexity of the Grid, service providers for the smart grid will assume that they are involved in the creation of the technological, financial, and operational approaches that help in the development of the SG infrastructure [36]. To improve electricity consumption, SG includes a new infrastructure. To enhance performance, continuous sensing and power rating can be achieved through advanced classifications that allow the properties to be deployed with greater loads [37]. In [38], the authors suggested that to prevent problems related to production, energy demand and proper handling of consumers, and it is necessary to change the traditional techniques and methods. The active service should be improved based on some detected standards and problems. The authors emphasized in [39] that the operating output is increased by choosing the lowest-cost supply unit with system controls. Also, SG assists consumers in controlling demand trends and ensuring flexibility by adjusting energy consumption and purchasing process. This trend will encourage customer interest in energy revenue, purchase and sale. SG was also chosen as an attractive modern technology due to its ability to provide current knowledge about energy consumption, different service methods and benefits. In [40], the authors show that SG includes large and distributed power plants and helps increase a variety of domestic energy services to customers by combining wind, heat, electricity, and carbon efficiency. Whereas, in [41], the authors have shown that SG generates energy at different levels (and prices), and customers can choose from competing bidders in a well-designed and managed market.

Thus, markets may play an efficient role in managing these variables. Regulators, creditors and consumers have the right to change the corporate law according to operating and economic conditions. For this reason, electricity, power, location, times, levels, and performance are some of the various network stats for real-time monitoring and supervision. The electricity purchase was considered among the Pillars and goals of modern SGs. In [42], the authors were proven the previous consideration related to electricity purchasing. This proof is based on an advanced infrastructure that will provide an integrated policy and customer service. This infrastructure allows monitoring of light, faults, artificial sources, and energy demand.

Future smart grids pose some challenges for a variety of energy demand and decentralized production. The role of consumers and producers can be managed simultaneously by the SG-end-users (so-called "Prosumers "). In future network service, prosumers are seen as an attractive solution for resolving many obstacles and challenges faced by SGs [43]. In [44], the authors suggested that the Prosumer Groups (ProG) strive to transform traditional customers into productive consumers, improve SG performance, and deliver an economical, logistical, and sustainable advantage. The authors in [45] have reported that the prosumers aim to generate and consume energy and possibly start sharing and spreading the extra power to other customers in the distribution system using edge technologies. To maximize the use of the edge technology, procedures, business models, and growth incentives, it is vital to understand the roles and priorities of consumers in the early stages of smart grid deployment [46]. In [47], the Prosumer SG functions and characteristics are chosen based on pre-creation energy consumption strategies. In [48], the authors demonstrated that the Prosumer SG functions and features are determined based on the pre-creation energy consumption strategies. These functions are the "engineer" who supports emerging technology and creativity, the "Green Prosumer," interested in innovative approaches for environmental purposes and the "value seeker," involved in economic benefits and Prosumer efficiency, consistency. Edge Computing Technology has been included as an attractive technology to acquire Prosumer goals. This latter is intended to improve privacy and data protection, enhanced operating output, improved market quality, stability, network management and infrastructure handling, low response time, data dissemination, more robust device performance and lower operating costs [49].

2.2 SG Emerging Issues

Given all the advances, methods, and techniques incorporated in the SGs, this emerging technology also poses a variety of important issues. Critical interests in SG can be generally defined as a technology essential for smart grid security (hardware, software, infrastructure, utilities, networks, sensors, and devices). In this context, this subsection seeks to reveal the main critical issues emerging in communications and information technology, sensors, estimation, automation system technology, electrical and electronic devices and energy storage systems used in SGs. The SG emerging issues as given as follow:

- Emerging issues in power electronics and energy storage technologies: Electronic control systems introduce harmonic distortion into the grid and making voltage distortion issues [50]. Indeed, the widespread use of electronic control interfaces (such as flexible AC transmission and high voltage DC installations) will be required to create smart electric power grids [51].
- Emerging issues emerging in automation sensing technologies: Smart Meter is an attractive automated energy system which indicates in real time, with two-way access and remote terminal units/interruption, energy consumption, price information and dynamic prices [52]. All components and devices in the smart meter system require additional identification numbers, which makes it more difficult to integrate

new devices, appliances, sensors, etc. with an increasing number of customers [53].

- Emerging issues in communication technologies: Smart grid communication systems need smart meters and edge sensors to communicate between appliances and the database. Smart meters include a modular, interoperable, reliable, scalable and efficient two-way communication backbone that requires duration and frequency [154]. The transmission and storage of information should be protected to prevent cyber-attacks [155].

The Smart Grid is an advanced and asynchronous digital power transmission system that consists of forecasting multiple complications, self-healing, adaptability, adaptation, and sustainable development. SG seems to grow, energy companies are gaining dynamism through smart meters. Switching to smart grids will change power generation systems that will encourage

Prosumers, and enhance the psychological and social changes of employees that make educated and energy-related life decisions. In this regard, the effectiveness of Prosumers in adopting the smart grid has been addressed in evaluation reports and studies. There are in fact a few methodological statistics related to the variables involved in general interests relative to the number of articles on business and innovation category studies. Some of the results of previous studies support and oppose the theory that clients value rewards. It provides some general guidelines for stimulating many approaches. Due to the large diversity of power grids in smart grid projects, the results are distributed entirely on the actual topic. The studies are based on social, economic, and cultural concepts that have monopolized generations of energy users achieving a smart grid is an urgent and important goal. The goal of this investment is to achieve positive growth and incorporate green energy, among many other aspects, that consumers are always concerned about. The literature explored the role of current technology in brand awareness. With regard to energy management and the sustainable use of consumer energy, the use of edge computing IoT architecture should maintain motivation as part of energy transfer. Prosumer's SG will encourage everyone to improve their strategic goals or gain a certain level of independence while enabling the smart grid with the ability to further reduce costs as appropriate. Fully automated economic or automated approaches certainly, demand management or extensive deployment of SG devices will have stability and logistical performance, which is essential. The biggest challenge for developing smart grid projects is the failure of integrative standards for the residential sector where there are enormous complications and where there is no similar goal, habits of prosperity and demand, requirements, priorities, and local regulations. Indeed, the adoption of advanced technologies lies in the incorporation of the Edge computing IoT and Blockchain is necessary to control the Prosumers. On the other hand, we provide a brief summary of our survey paper that is based on different interests: concepts, applications, field survey and theory. Table 1 shows and summarizes the different level of use in each interest and area. This issue has the potential to cause prosumers to become disconnected and isolated. This isolation may result in erratic pricing in different locations. Even the model is effective for local markets with fewer participants of the scheme and the need for global outstretch.

Table 1. Comparison of existing survey papers

Areas	**Concepts**	**Applications**	**Field Survey**
Prosumer Smart Grid	3	0	3
Prosumer Energy Management	3	3	3
Prosumer Models	0	0	0
Prosumer Concepts	3	3	0
Prosumer Techniques	2	0	0
Economical	0	0	0
Social	0	0	0
Technological	3	3	3
Evaluations	0	0	0
Buildings Clusters	2	0	0
Demand-Response	1	3	1
Exchange In SG	3	0	0

Areas	**Concepts**	**Applications**	**Field Survey**
Market	0	2	0
Multi Agents	0	2	0
Energy Trade Concepts	3	3	3
Energy Trade SG Concepts	3	3	3
Blockchain SG Architecture	3	2	1
Edge Computing Methods	3	2	3
Infrastructure	0	0	1
Blockchain Prosumer Architecture	2	0	3
Blockchain SG	2	0	0

3: Non-Use, 2: Low-Use, 1: Average-Use, 0: High-Use

2.3 SG and Energy Prosumer

The energy consumption concept in the energy sector seems to be well known. If it is well developed in many markets, the competitive advantage of becoming a customer becomes clearer. Competitive systems, such as photovoltaic power plants, Combined Heat and Power (CHP) plant and trade winds, have been chosen as attractive sources for supplying consumers [56]. SG can considerably enhance energy consumption, energy management, distribution and productivity improvement and incorporate a growing amount of renewable sources. Certain energy policies aim to make renewable energy more cost-effective, but the obstacle is how you can evaluate the costs of incorporating renewables in an energy system. Two methods of cost-assessment, the Levelized Energy Cost (LCOE) and Energy System Analyzes (ESA), are used for energy consumption evaluation [57]. Also, the SG system includes several components for the continuous distribution of energy. This includes smart technology, digital networks, two-way communication, integrated management methods, requirements and regulations, and efficient consumer integration. Some of the first systematic studies were in conjunction with SGs based on comparison consumers [58]. The authors in [59] reported that Prosumers has an average MW/h in a given account through solar energy consumption with an increase in energy prices. Alternatively, power outages can also be resolved from time to time by adopting a power supply storage solution. In [60], the authors suggested that prospective activities convert conventional energy systems into smart energy systems by incorporating Edge technology. Where investigative regulations have been discussed around five different ways of the role of the Prosumer in the smart grid. The prosumer roles include the Market Participation Strategy (MPS), Strategic Analysis; Competitive Advantage; Economic evaluation and benefits; Business research. Also, the Prosumer is a potential solution to achieving trade in renewable energy [61]. In [62], the authors have shown that energy providers have several objectives with the integration of Prosumer features: providing electricity demand for consumers, integrating IT, and reducing prices. According to energy distribution and management, Community Prosumer Groups (CPGs) have been compared to the consumer community. Potential Prosumers were interested in improving energy efficiency by controlling energy production, hours of use and storage capacity [63]. A detailed overview of the analysis publications allowed us to identify the prosumer smart grid classes (see Figure 1). Several other experts have spoken separately about these problems: early competitors, network smart market strategies, and Prosumer creativity. Indeed, the Prosumer concept has been overcome through numerous studies [64]. One such research suggested an improvement in Prosumer alliances created to improve their energy product offerings while reducing the likelihood of an economic loss at the same time when performance drops below the contractual level [65]. In simulating practical Prosumer behavior, basic environmental details were used for a specific area. The algorithm makes alliances with high efficiency and low volatility in energy production depending on the spatial correlation structure [66]. The results indicate that the alliances that were created provide the network with less capacity, less storage. Blockchain and Big Data are chosen as attractive emerging technologies for SGs. In [67], the authors discussed the blockchain flexibility approach in SGs. The proposed approach focuses on blockchain and smart contracts as an intermediary between energy suppliers and electrical customers to reduce costs, increase transaction speed, and improve user information protection.

Big data has been collected as an attractive solution to manage large amounts of information collected with study groups.

Figure 2 shows ProSG's various classes: the Prosumer Engagement Class (PEC) and the Prosumer Management Class (PMC). At PMC, many topics are presented in the literature, such as market design, roles, goals, alliances, motivations and management. Whereas, at PEC, we distinguish that other topics are presented, such as economic, technological, social, relationships, evolution, and engagement.

Figure 2: Prosumer-Smart grid classes

Most researchers have focused on Prosumer management and energy exchange strategies, partnerships, expectations, and incentive programs. They highlighted the need for new innovative approaches to address these challenges more efficiently (Table 2). Prosumer management consists of the following aspects:

- Communication/negotiation: for approval and common consensus among beneficiaries.
- A normative/ethical: to maintain responsibility for energy share distributions.
- Assessment of prosperity: for influencers and influential actors who do not meet expectations

Table 2. Prosumer smart grid (ProSG) agent goals

Prosumer smart Grid (ProSG) taxonomy	**Prosumer Engagement Class (PEC) Concepts**	**Prosumer Management Class (PMC) Concepts**	**ProSG concept : Related works**
Prosumer Market Design **(ProM)**	****	It is characterized by consumers who provide services to the network and turn into active consumers. Depend on the integration of the consumer product network, peer-to-peer models, and consumer society groups.	The authors focused on a survey to promote modern technological developments and aim to inspire awareness of further liberalization of the electricity market, especially in areas closer to consumers [76]. A Prosumers agent was presented and explained to consume and produce energy [77].
Prosumer Alliances **(ProA)**	****	Ensures more power to the grid with less diversity, thus using less storage and wasting less energy	A consumer alliance is included to analyze accurate weather data from specific area stations to simulate each consumer's actual production and consumption patterns [78]. ProA agents aim to collect the required data according to advanced algorithms [79].

Prosumer smart Grid (ProSG) taxonomy	**Prosumer Engagement Class (PEC) Concepts**	**Prosumer Management Class (PMC) Concepts**	**ProSG concept : Related works**
Prosumer Engagement (**ProE**)	Enables consumers to transform into active consumers and build strong relationships with other entities in the network	***	ProE is included in SG as a variety of electrical resources to engage large power plants, renewable energy systems, energy conservation, reaction needs, and electric vehicles. The obtained results show that, by aligning with many of SG's goals, ProE will take a "stronger" position in future energy markets. The actual launch of SG depends on how customers accept SG service [80].
Prosumer Social Economical and Technological (**ProSET**)	Consumer behaviour is affected by ProSET. It seeks to establish exchanges and attitudes in the energy field regarding the value and influence of other households.	***	To achieve greater acceptance of a ProSG for marketers, the economic and social environment analysis is necessary. The social perspective of future research is also an important aspect. It may require a specific area of business service, safety, policy, and job initiatives. The launch of emerging technologies alone does not promise consumer acceptance, except in the case of accelerated technological growth, because consumers find this to be at premium prices [81].

Prosumer smart Grid (ProSG) taxonomy	**Prosumer Engagement Class (PEC) Concepts**	**Prosumer Management Class (PMC) Concepts**	**ProSG concept : Related works**
Prosumer Management (**ProM**)	***	ProM aims to produce and share surplus power with the Grid and other ProMs.	ProM agents were chosen as an essential partner in the future because of their vital role in managing peak demand. Moreover, during power management, it is crucial to test ProM behavior patterns. Examine all the variables that govern peer activity and relationships within the smart grid in identifying grid demand features and energy needs expectations [82].
Prosumer Goals and Motivations (**ProGM)**	***	ProGM has two main goals: scheduling offline required electricity (in advance). The expected energy consumption is performed in real-time	ProGM must consider the supply and use of uncensored consumer ability to prepare for expected energy use. ProGM aims to change the energy structure and enable the consumer community to consider the economic, environmental, and living standards of each consumer [83].

The relationship between the provider and the Prosumers is vital in the smart grid infrastructure because it affects the productivity and use of electricity generation and the right balance between supply and demand. It will also be considered sufficiently coordinated to ensure the willingness of all parties to work cooperatively so that energy exchange is applicable for the long term [68]. In [69], the authors show that prosumers have gained significant interest due to their ability to perform in the energy market as a supplier and customer. The authors in [70] reported that energy market infrastructure allows customers to become participating suppliers and forge close links with other companies within the market. Consequently, the energy market infrastructure aims to encourage prosumers to achieve and enhance flexibility, enhanced competitiveness in the energy industry, advanced systems and equipment regulation, economic benefits, economic rewards, low energy costs, and transparency [71]. The authors in [72] mentioned that prosumer engagement improves customer preferences and enhances the benefit-seeking goals that lead to a successful SG operation. Indeed, the prosumer's objectives have been defined based on accessibility and legislation of emerging technologies, sustainability benefits, financial gain, statistics, and energy consumption. To raise public awareness of the smart grid's benefits and manage the trust needed to improve consumer participation stakeholders, energy demand can be ordered through efficient communication strategies [73]. The authors in [74] suggested that the prosumer engagement enhances customer priorities and facilitates market goals for facilities that lead to effective smart grid activity. It stimulates the user to approve and involve emerging technologies by introducing advanced innovations, environmental benefits, financial opportunities, fee statistics, energy use, security, and other data. In [75], the authors recommended considering social, economic and technological aspects when analyzing smart grids.

2.4 Energy Domain Prosumer Classifications

In a smart city, the energy sector plays a similar task to energy engineers. Energy prosumer has been identified as an attractive research issue because of its importance to solve energy consumption systematically. Indeed, energy prosumers include assembly lines, renewable energy plants, and Energy Storage Systems (ESS) for electricity consumption [84]. The authors have shown in [85] that prosumers include several renewable sources such as biomass, solar and wind power to produce and use electricity. During the peak period, prosumers use energy from external sources (Grid). In contrast, excess electricity can be supplied by self-production of coal or in local oil markets. The authors in [86] mentioned that each energy Prosumer is defined as Prosumer Production-Oriented (ProPO) or Prosumer Consumer-Oriented (ProCO). Some resource types are noted as listed in Smart City (see Table 3) [87]:

- Energy Generation Company (EGC): Commercial energy generators generally collect electricity from existing energy generators and market them to local energy consumption entities. The power company buys energy from separate power plants.
- Home Energy Storage System (HESS): Energy storage devices for households that own and use reusable energy on demand obtained from small renewable energy plants such as solar or wind power plants.
- Building Energy Storage System (BESS): is designed for energy saving storage and utilization (renewable energy Plants).
- Electric Vehicle Charging Station (EVCS): Infrastructure requires power sources, batteries, and computer networks for charging. The electric vehicle's charging station collects energy from the power source and sells it to the car, storing the point in the car via the battery. It also acts as an intermediary in selling electricity between electric vehicles, homes, networks, etc.
- Green Electric Vehicle (GEV): EV is only used to include green vehicles with a battery and an electric motor inside the car and capable of transforming velocity into electricity and maintaining it in the artillery during service. The electric vehicle markets power through the charging point.
- Prosumer Smart Home (PSH) without ESS: PSH is provided only with the device or related components that can control the power required and consumed by the network without installing and considering ESS.
- Prosumer Smart Buildings (PSB) without Building Storage System (BSS): PSB is limited to similar systems or devices that can manage power supplies from the power grid.
- Solar Energy Company (SEC): Energy companies produce a large proportion of renewable energy. Residential solar companies have a capacity of more than 1 MW. The power supply is calculated by the Prices of Electricity Sold (PES) for typical and electrical generators.
- Wind Power Generation Company (WPGC): Wind farms provide wind energy. Domestic wind turbine production is about 1031 MW. The energy supplied is calculated by the prices of electricity sold (PES) for typical and electrical generators.
- BSS with Large Capacity (BSSLC): stores and uses renewable energy to increase economic productivity. According to some statistics, many companies have installed storage solutions with a capacity of more than 1 MW installed, with an agreement strength of about 20 MW each year [88].

Table 3. Energy prosumer classifications

Classifications	ProPO	ProCO	Energy Prosumer Categories
WPGC	[?]	************	Po-Energy Prosumer
HESS	[?]	[?]	Energy Prosumer

Classifications	ProPO	ProCO	Energy Prosumer Categories
SEC	[?]	************	Po-Energy Prosumer
BSSLC	[?]	[?]	Energy Prosumer
PSB	************	[?]	Co-Energy Prosumer
BESS	[?]	[?]	Energy Prosumer
PSH	************	[?]	Co-Energy Prosumer
GEV	[?]	[?]	Energy Prosumer
EVCS	[?]	************	Po-Energy Prosumer
EGC	[?]	[?]	Energy Prosumer

3. Peer-to-Peer Energy Trading

3.1. Prosumer and Consumer Cases

Peer-to-Peer (P2P) energy exchange is a peer-sharing facility where renewable energy consumers and small cooperative services provide consumers with energy in homes, offices, etc. Peer-to-Peer (P2P) energy exchange is a peer-sharing service where consumers of renewable energy and small cooperative services provide power to consumers in homes, offices, etc (Figure 3). Indeed, P2P technology provides an opportunity for a new generation of models in the energy sector [89]. The authors suggested in [90] that the energy prices will adapt to a competitive and automated economy due to the shift in electricity delivery technologies and trends. At the same time, P2P power generation is traded across the energy industry and is now evolving. The authors suggested in [91] that P2P assists individual consumers to become consumers and exchange surplus resources with competitors. The use of on-site PV characterizes Self-consumption. In this vein, energy storage will improve self-consumption. The obtained results showed that the intermittent effect of renewable energy production leads to an uncoordinated distribution of energy to/from the grid. Thus, utility networks cannot enhance reward/punish clients. The authors highlighted the need to allow consumers to self-organize into a group to increase their personal and group use [92].

Figure 3. Prosumer energy management scheme

The authors stated in [93] that the major components and technology involved in P2P energy trade are listed and categorized according to their activities. As shown in Figure 3, Figure 4 for P2P energy circulation, four-tier levels are suggested.

- Prosumer Power Grid Level (PPGL): Contains all power grid units like feeders, adapters, intelligent meters, drawings, etc. These units constitute the physical infrastructure for energy delivery for the introduction of P2P energy trade.
- Prosumer Information and communication technology Level (ICTL): Includes network equipment, protocols, software, and data distribution. Sensors, wire/WLAN connections, routers, switches, computers, and other machine models are also standard network equipment. There may be many collaborative mechanisms such as knowledge sharing and data exchange. The flow of knowledge indicates the senders and recipients and the quality of each message between communication appliances.
- Prosumer Management Level (PML): Consists mainly of power grid management functions. In this layer, efficient energy supply is managed, and energy flows are regulated. Active energy management is an example of potential control tasks within a control system, voltage regulation, and frequency control.
- Prosumer Business Level (PBL): aims to engage with peers and with private entities. This primarily consists of investors, manufacturers, Distribution System Operators (DSOs), and regulators in the electricity industry. Different types of business strategies can be built to integrate different forms of P2P energy circulation in this layer

Figure 4. Peer-to-Peer energy trading levels

3.2. P2P Energy Trading

Due to the issues with traditional distributed energy trading and the blockchain-based paradigm proposed (i.e., infrastructure-based P2P energy trading), there is a need to include grids with technology for energy trading. For example, in an ad hoc P2P energy sharing model, local micro-grids will be combined with potential for energy suppliers using a blockchain-based network (Figure 5). As a result, customers can not only import from another consumer, but they can also opt to purchase electricity from traditional power plants [94]. Because of the blockchain's immutability and distributed existence, this model ensures that all transactions are open to all prosumers and large energy providers, especially governments. The government should have the forum in order to gain ownership over the energy sharing market [95]. That will aid in increasing the appeal and opportunity for all parties concerned. Since distributors will be compensated for these facilities, this model will provide more business opportunities for traditional suppliers. The architecture of this design indicates the presence of smart devices on both the consumer and power supply sides. The structure is classified into four levels: Tier power grids, which include both major companies and countries that either generate or distribute energy [96]. Data transfer is where much of pre-negotiation and communication will take place. The transaction is executed in three stages. First, the consumer expresses his intent to purchase energy. Sellers apply their offers, and the buyer chooses one of them. Another important line of communication is between the vendor and the Grid. The seller must agree to a deal for distributor services. The blockchain layer is responsible for storing all transactions [97].

Figure 5. P2P energy trading

3.3. Infrastructure-Based Energy Trading

The centralized organization manages traditional electricity trading. However, prosumers do not need centralized authority for P2P transactions. Prosumers may directly interact with each other for energy exchange in the assumption that physical ways of transmitting energy occur [98]. For e.g., two adjacent houses will communicate via a wire cable, and the energy can then be transmitted directly. The premise in the infrastructure-based P2P energy sharing paradigm is that prosumers have smart meters and IoT sensors mounted on the object on which they are purchasing energy (e.g. Home-To-Vehicle-V2H/H2V) [99]. As seen in Figure 6, these devices interact with one another through the blockchain in order for the transaction between the two entities to be efficient. Another presumption is that the prosumers have the functional means to exchange resources with one another. The proposed architecture in [100] for a pure P2P trade does not have to include any outside party in the negotiation process. Prosumers and consumers interact with each other from transactions and behavior. If consumers have the material resources to transmit electricity, they can conduct transactions without intermediaries. Since specific conversations take place on a different network, this removes the communication strategy from the blockchain system [101].

Another case that fits into the infrastructure-based P2P power-sharing model is the Brooklyn microGrid [102]. It depends on a limited number of Prosumers and customers (for example, five Prosumers/consumers) related to each other. By using smart meters and e-wallet, consumers may sell excess electricity to neighboring customers. The transaction is executed using self-executing contracts, and each participant has access to all transactions. Users can decide the total cost they are willing to provide and prioritize the type of energy required (i.e., conventional or Renewable Energy). The Micro-Grid outages mentioned here are premature, and some operational issues may appear. One of them is to provide the physical infrastructure for energy conversion and global scale (for example, dealing with situations where the seller is not close to the buyer but needs to sell the energy) [103].

Figure 6. Infrastructure-based energy trading

4. Blockchain Technology in SG

4.1. Motivations of Applying Blockchain in SG Paradigm

SG is considered an advanced strategy that combines digital and network computing technologies to transform and modernize the traditional grid heritage in power distribution and a more reliable, efficient and insightful transmission network [104]. These modernization changes have arisen due to severe climate change and the need for renewable energy sources. The overarching goal of these transformations and modernizations is to change the energy environment by combining distributed energy supply with sustainability and utilization and reducing dependence on generations based on fossil fuels. The old traditional network serves customers with its long-distance transmission lines, while the innovative network model brings producers and consumers closer together by installing renewable suppliers as independent distributors [105].

Although the smart grid and the energy internet are intended to adapt to dispersed and centralized energy generations, one of the significant drawbacks to the current architecture is the central structure. Energy generations, transmission and distribution networks, and markets depend on primary or intermediate institutions. Smart grid elements connect and coordinate with prominent organizations that can track, receive, data process and assist all aspects with adequate control signals in this centralized environment. Moreover, the energy is usually transmitted through a long-range network to transfer the powers to the end-users through the distribution network [106].

Unfortunately, given the penetration of renewable energy and the ever-increasing number of components, the latest architecture for smart grid systems raises some questions. Scalability, scalability, high computing, connection pressures, availability attacks, and the inability to monitor potential power systems with many components are among the considerations [107]. As a result, moving to a decentralized infrastructure is an intelligent network direction that offers more complex, insightful and proactive functions. The network infrastructure also evolves and advances towards a fully integrated network with clustered configurations to increase complex interactions across all components of the innovative network systems. The synchronization and usability provided by EI also contribute to the most economical, efficient and reliable innovative network system service [108].

The energy market is rapidly increasing as the current topic progresses. The SG was intended to guarantee reliable power delivery, low losses and good efficiency, and energy supply reliability. The idea allows individuals to produce power on a limited scale and supply it to the grid. However, the concept brings complexities to the current infrastructure, such as how a transaction between these generators and users is handled, checked, and registered [109]. This segment demonstrates how blockchain can be used to process innovative grid transactions. Smart contracts are used to carry out transactions, and the network functions as a transaction verifier. The blockchain ensures transaction immutability, ensuring that any transaction between generators and consumers is completed. It also gives marketing background immutability, which may be helpful when auditing or resolving a transaction conflict [110].

4.2. Blockchain Evolution and Structure

The last twenty years have seen a remarkably rapid rise in blockchain technology, from the first Bitcoin protocol (blockchain 1.0) and the advance to Ethereum (blockchain 2.0), already referred to as killer denominations (Blockchain 3.0) (Figure 7). As a result, the infrastructure has evolved from a simple database to a fully dispersed cloud storage network [111]. Ethereum's potential blockchain lies in developing blockchain technology from a database-only cryptocurrencies service to a more general infrastructure capable of operating multiple decentralization applications in various fields, such as financial services and any sector that could benefit from digital currencies. The first and second generations of blockchain encountered several challenges that prevented their rapid adoption [112]. As listed above, proving possession of an asset without central authority through the consensus mechanism is a time-consuming process. To execute any transaction on the Ethereum blockchain, each node must compute all of the included smart contracts in the network in real-time, resulting in a slower transaction pace. The blockchain consists of blocks arranged in sequence in time, secure, and linked using a hash function. The block is named in time so that it cannot be changed. A block is made up of a group of transactions [113]. A transaction in Bitcoin is the transfer of ownership of funds. However, in our case, it can be exchanged for the payment of electricity. The hachage function is a mathematical function in one sense that produces a constant output regardless of the input. A slight adjustment in the information can lead to significant changes in production. The difference is also exceptional because it is easy to calculate exit based on the entry, but not otherwise. When the block is complete or it is time to create a new block, it is penetrated with a specific hachage function, H (x), where x is the current block number [114]. The hashtag is then stored in the next block, to form a "chain". The procedure was repeated before the last block so that the slight change in the block would be notified quickly because the change is invalid. Bitcoin can be used to change the owner of a currency or to transfer money from one individual to another. However, instead of a true identity, the former and subsequent owners are represented by a specific identifier known as the title [115]. The address is derived from the public key of the private-public key. As a result, the network will quickly verify the health of the property owner. Since the blockchain records the complete history of the purchase, it can be traced back to its beginning, eliminating the problem of double spending.

Figure 7. Uprising of Blockchain technology

4.3. Blockchain P2P Energy Trade

The introduction of prosumers and SGs opens up new electricity trading opportunities, allowing participants to conduct energy transactions (including prosumers, grids and energy storage). Since energy is the most critical economic development system, this paradigm shift in energy trading necessitates establishing a stable, reliable structure and promotes energy economics [117]. Furthermore, trading mechanisms should become more decentralized to safely open up the market to more participants (as illustrated in Figure 8).

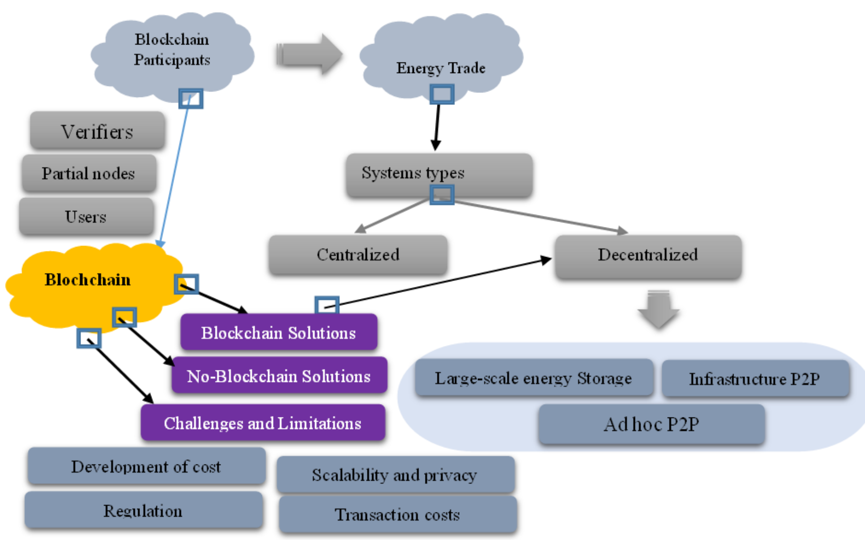

Figure 8. Blockchain P2P energy trade structure

Blockchain is an exciting technology that can provide a distributed, robust, stable, and privacy-preserving platform for energy trading. The concept of blockchain leadership is to provide transparency and a distributed chain as a data network to process verifiable transactions as required effectively. Since the database may be spread among all parties, the blockchain also has a clear consensus [118]. The blockchain is made of blocks, and each block includes a certain number of transactions known as block size. The blockchain is divided into five planes: network, consensus, storage, vision, and side planes. The network plane is in charge of connectivity, while the storage plane stores the whole blockchain. The level of consensus is the most important of them as it is responsible for seeing a concurrent, all-encompassing network [119]. There are three kinds of participants in the blockchain. The Verifiers are validated by verifiers who solve a cryptographic problem (through a process called mining). Partial nodes do not join in the authentication but maintain a network-wide backup of the register. Users are the participants who create the transfers and provide the contacts graphics to extract the data. Mining creates a block that is added to the chain. The block is split into two parts: transaction details and hash values [120]. The advent of prosumers and smart grids creates different electricity trading opportunities, allowing participants to conduct energy transactions (including prosumers, grids and energy storage). Since energy is the most critical economic development system, this paradigm shift in energy trading necessitates establishing a stable, reliable structure and promotes energy economics. Furthermore, trading mechanisms should become more decentralized to safely open up the market to even more people involved. Blockchain is an exciting technology that can provide a distributed, robust, stable, and privacy-preserving platform for energy trading [121].

Blockchain is chosen as a promising technology for peer-to-peer energy transfer; there are multiple barriers to its widespread adoption:

- Scalability and privacy: Blockchain is still yet to demonstrate its scalability, reliability, and protection.
- Development of cost: One significant obstacle is the blockchain's development cost. A transaction verifier, for example, requires a considerable level of processing and intern power, which adds to the expense of the conventional database system.
- Regulation: Blockchain is beginning to show promise in available electricity exchange networks. However, the proposals presented include organizational problems such as load handling, integration with centralized control, and alignment with centralized networks
- Transaction costs: After any calculation, the transactions are added to the blockchain. This is a complex and time-consuming process.

Various goals tend to define the technological, organizational and economic architecture of developing blockchain-based infrastructure and services. The following are the objectives of the technical specifications:

- Scalability: Enable the models to be more modular to include newer players.
- Decentralization: is not required by design. This vein can be used to build energy exchange models where there is no central authority.
- Variety: Various sensors can occur. For example, electricity can be exchanged between two vehicles or two homes. To support a variety of models, models must integrate a wide range of devices and technologies.
- Intelligence: There are two advantages to intelligence. The first is that electricity can be delivered at the most affordable (or cheaper) possible. There must be an advanced bidding mechanism, and the customer must have the ability to choose.
- Internet of Things (IoT): At the center of the decentralized blockchain are IoT computers. For example, electric vehicles are equipped with Internet of Things devices and contact sensors in the case of electric vehicles.

4.4. Transaction Workflow

Workflow is divided into three main parts. The term "energy deal" refers to any communication and negotiation between the buyer and the seller [122]. The publication of the user's offer/demand over the network is an example of interaction before a trade. Various mechanisms can be used to protect data and confidentiality (Figure 9). Seller Bidding In bids between the buyer and the seller, recognition is performed to determine the user's right to deal with respect [123].

Entities: They are involved in the energy trade and divided into three classes. These companies will be able to use smart meters and the blockchain.

- The central utility manager: consists of the community, electricity providers, and network owners who own the physical and technological resources for energy sharing and transmission. It is responsible for formalizing global order and organization.

- Power generators: use both conventional and renewable energy sources - those with large energy reserves that supply power to the grid. Commercial power suppliers include national grid controllers, small grid owners, and turbine owners.
- Consumers/prosumers Energy: Prosumers have the added benefit of producing and distributing excess electricity to other consumers in the grid. Consumers/Prosumers may be private homes, hybrid vehicles, or large structures.

One way to maximize consumer value is to accept payment methods. As a result, the consumer will have more motivation because he will gain quick rewards and investment potential. Second, there could be a way to encourage more repeat consumers. For example, if a consumer sells to the government, the buyer can be paid in a Power, cryptocurrency, or bill change.

Real-time monitoring and supervision are critical in peer-to-peer energy trading. The demand answer is the idea of shifting energy load from low-demand users to high-demand customers. E.g., the household needs less energy in the morning than in the office building. Similarly, the condition is inverted at night. As a result, the power can be dispersed as required.

Figure 9. Blockchain-based energy trading Taxonomy

4.5. Prosumer Energy Management Algorithms

One of the important and exciting features of the SG is the efficient use of the power system features. Various optimization techniques are used for prosumer-based energy management and smart grid features [124]. One of the SG's important and exciting features is the effective use of power system technologies. For prosumer-based energy management and SG applications, various optimization techniques are used [125] For example, the authors reported in that to achieve streamlined results, usage, costs, and satisfaction of all stakeholders, Prosumer Energy Management (PEM) should have relied heavily on optimization algorithms. Some descriptions of different modelling methods for energy conservation and PEM optimization algorithms are discussed, as shown in Table 4.

Table 4. Comparison of optimization PEM techniques

Prosumer-Optimization Technique-POT	**Domain and Desired Objective**	**Model**	**Findings**	**Ref.**
Prosumer Genetic Algorithm (PGA)	Domain: Residential energy management system It is concerned with the cost of electricity and reducing the peak to average ratio	A hybrid-renewable generation and ESS load were controlled and handled using a Genetic Algorithm (GA).	We are dividing devices into clusters. User comfort is not regarded.	[126]-[127]
Prosumer Mixed Integer Linear Programming (PMILP)	Domain: Energy-management System and Grid connection Aimed to reduce the peak to average ratio cost using renewable energy.	The energy management approach for residential based on renewable energy.	Peak to average ratio cost reduction was achieved.	[128]- [129]

Prosumer-Optimization Technique-POT	Domain and Desired Objective	Model	Findings	Ref.
Prosumer Particle Swarm Optimization (PPSO)	Domain: Appliance scheduling. Aimed to reduce energy costs and improuve consumer satisfaction.	Produce electricity and handle Energy demand.	A reasonable deal was done regarding benefits and User comfort.	[130]-[131]-[132]-[133]
Prosumer Linear programming (PLP)	Domain: Residential energy management system. Tend to reduce the electricity bills and peak to average ratio.	Energy use scheduling to avoid maximum load times based on ESS.	Tasks are to use ESS off-grid and then modify them during peak hours.	[134]- [135]-[136]-[137]-[138]-[139]
Prosumer Integer Linear Programming (PILP)	Domain: Residential energy management system. Appliance scheduling.	A scheduling approach to controlling home and neighborhoods energy demand.	The integration and management of electricity usage trends are achieving a significant reduction in peak periods.	[140]-[141]-[142]-[143]-[144]

4.5.1. Prosumer Genetic Algorithm

Genetic algorithms are considered an attractive research issue due to its ability to solve the DSM and Complicated Economic. Furthermore, PGA is applied to increase energy transfer efficiently at a calculated level. GA has been involved in many areas of the energy system to solve optimization problems. The goal of the schedule should be to meet all plant and system constraints while meeting the demand for load at the lowest operating cost. Genetic engineering and development focus on PGA improvement strategies. In [126], the authors presented the PGA as a potential solution due to its ability to overcome the complex problem of improvement and is efficiently employed in various fields and sectors. The authors stated that the diversity of problem formulation is one of essential advantages of PGA compared to other optimization techniques such as linear optimization or dynamic programming. This means that the PGA can deal with different types of restrictions. First of all, the strength of each Decentralized Generators (DG) must be kept within its range. Handle various types of prosumer energy management concerns. The authors proved in [127] that PGA controlled and supervised in real-time Decentralized Generators (DGs) and load transmission based on models and time constraints associated with start time rather than optimum efficiency. A GA-based approach was proposed to control energy demand. The load usage is governed by taking into account the set point: the load that the consumer wants to operate within the cover of the set point. This proposed approach aims to control the use of the pack by observing a specific issue, that is, the prosumer payload is willing to work within the maximum specified point.

Use of pregnancy depending on the distributed obstetrician, a specific point or limit is determined for pregnancy consumption. Different situations assess the effectiveness of the device.

4.5.2. Prosumer Mixed Integer Linear Programming

For the design of high-dimensional and non-linear systems, the PMILP was proposed. The classic principle of operation is applied to accelerate the cycle towards the device's expandability. Indeed, PMILP is a methodology used to automate storing electricity in an intelligent system. PMILP differs from other dimensional methods of programming, which contain both actual and incorrect variables. The PMILP was introduced for designing high-dimensional and non-linear systems. The classic operating concept is applied to accelerate the process toward the expandability of the device. PMILP is a method used to optimize the handling of energy in a smart network. PMILP differs from other dimensional programming methods, which deploy actual and incorrect variables [128].

Many innovations usually generate just one ideal solution, while others may create many solutions. In [129], energy efficiency algorithms focused on the recommended PMILP was proposed to reduce costs and conserve electricity. Indeed, the authors proposed the PMILP-based energy efficiency algorithms to reduce costs and save electricity.

The results showed that the total cost of the optimization problem related to energy consumption was reduced through optimization techniques. PMILP Algorithm was used to encourage average users or residents to change purchasing costs to keep costs down. The authors explored and measured the concept of time limits.

4.5.3. Prosumer Particle Swarm Optimization

PPSO has seen growing numbers of applications for SG domains; the three largest application areas are scheduling, active control and network layout schedule. Indeed, SGs are used in PSO variants, including genetic SPO, unexpected PSO, and quantitative PSO. PPSO is often used in the smart grid to control electricity. A Particle Swarm Optimization (PSO) algorithm was proposed in [130] to minimize energy expenses for economic transmission issues related to demand exchange and for a random process that begins to create a series of alternatives. Indeed, PSO was also presented in to reduce operating costs and energy efficiency in conjunction with natural gas networks. They deployed PSO to implement a natural gas generator for the small grid to address problems in clean energy supplies and reduce the load and congestion of the gas. To prevent pollution and balance payments, the efficient distribution of all digital networks must be synchronized with the electricity grid. A transition is made to use PSO to address the related network issue.

In [131], PSO has been shown to outperform some standard methods used based on Information Engine Services (IES) and based on operating expenses appropriate for IES. The authors included challenging PSO improvements that converge faster and require less computational time. In [132], the authors discussed the PSO improvements, such as the fast convergence at less computational time. In [133], PSO was applied to obtain the optimum energy flow for renewable energy wires.

4.5.4. Prosumer Linear Programming

The PLP optimization algorithm was chosen as an attractive design method for storing electricity for the smart grid. PLP was used as a linear function of decision variables to find the correct approach to objective function problems and constraints. Many scientists have used PLP in various energy storage systems. Linear programming (LP) is used to increase daily consumption from peak demand. For example, in [134]-[135], the authors deployed the LP as a consumption scheduling for shaving peak load at home. The authors also suggested a network in which the grid, home, power plants, and integrated power management system are interconnected. LP was proposed in [136]-[137] to maximize energy requirements using green energy supplies in different regions. The authors also attempted to highlight the difference between energy production and end-use by utilizing the LP and the power grid. The planned power grid model enables sustainable utilization and urban solid waste use [138]-[139].

4.5. 5. Prosumer Integer Linear Programming

The PILP is another smart grid practice for improving electrical electricity systems. PILP differs from LP, because only numerical and binary values can be used. Similar to LP, ILP can be used to express other questions. Each vector is continually limited to one continuous period, which is the functional area of the LP model [140]. If the variables are bound to valid values, then the structure is PILP. Since the region is realistic, the ILP model is fundamentally different from the LP model. It is important to remember that these models can be explained by various LP sub-processes and are very comprehensive in practice as a vital LP programming implementation field.

For both the electrically transported equipment and the displacement over time, the authors suggest a demand management system using ILP to increase the load for end-users in smart grids [141]. The authors propose a demand management program using ILP to increase the burden on smart grids for consumers for both the electrically transported equipment and the movement over time [142]. Three major components of the planned network are smart meters, appliance interfaces, and home appliances. To capture customer data from devices and usage plans through an interface, smart meters play an essential role in the proposed scheme. The smart meter was made using the data optimization algorithm obtained [143]. The planned network has three major components: smart meters, appliance interfaces and home appliances. Smart meters play a significant role in the proposed system to collect consumer data from devices and consumption plans via an application. The smart meter was developed using the algorithm achieved for data optimization [144].

The order scheduling method is described as a linear maximization feature of the mathematical formula to reduce the daily load.

5. Open Issues and Future Directions

Demand response and market management for unexplored areas is still under study, and applications based on machine learning for energy efficiency and cost analysis may include peer-to-peer energy trade. For example, a real-time billing system can optimize energy pricing based on current and potential energy prices (forecast) and charge the consumer accordingly. The blockchain is viewed as black box in most blockchain solutions. For example, many strategies [146] [145] use smart contracts as the blockchain protocol to grow the architecture. This limits the leverage over the overall architecture and performance of optimizations that cannot be made to the blockchain used in smart contracts. In the future, instead of using the blockchain as black boxes, blockchain could adopt a problem specific approach to energy trade.

There is a need for a network in which all prototypes can operate as a common framework and adapt their behavior to consumers' needs. For example, consumers must be able to sell electricity domestically and globally for large-scale energy storage systems.

The traditional architecture of the energy supply smart meter and every other revolutionary system are not used in blockchain. Many prosumers/consumers are eager to adopt this architecture. Given that most of the energy sharing frameworks presented to us presume that prosumers and consumers have intelligent devices. This new architecture blends conventional design with a cryptocurrency may be implemented. Consolidated energy trade by a group of consumers is outperformed by the inefficiency and robustness of operating individual consumers as autonomous firms in terms of renewable energy supplies. In addition, the power source for individual consumers may be insufficient to handle conventional power generators and may be unpredictable due to climatic conditions.

6. Conclusion and Future Works

This paper focuses on Prosumers SG and the main features examined with regard to monitoring functions and communication capabilities. Current and homogeneous technologies for Prosumer SGs require an additional attempt to achieve an independent and decentralized concept of intelligence level. To improve connectivity through the continuous creation of Prosumer SG, IoT edge computing was detailed and discussed. Indeed, several open issues and technological challenges related to energy management in the future were identified. In this context, the new challenges will provide the possibility to develop potential research in the industrial and professional fields. The concept behind this research is that the deep knowledge of SGs Prosumer and its interactions will allow consumers to properly evaluate issues/solutions and implement SG innovations such as blockchain structure and IoT edge computing. Based on our review, we have highlighted several studies, which include smart, public markets, household energy demand from clients and stakeholders, and energy demand for the service provider. Furthermore, we have presented the concept and the techniques used in the literature to manage the energy based on ProSG. The most important techniques deployed and evaluated by the authors are detailed in this survey paper such as PGA, PMILP, PPSO, PLP, and PILP. Moreover, the P2P Energy trading was detailed in both cases prosumer and consumer. On the other hand, we introduced the edge computing systems in IoT where Edge Computing IoT architecture, information processing in ProSG, edge computing smart home model, and future energy management systems are described and detailed. In potential improvements, it is highly suggested that stakeholders and the market be combined with the blockchain to ensure consumer efficacy and to improve the multidisciplinary electrical home appliances. In ongoing studies, SG security requirements will be strengthened. Blockchain and Edge Computing technology may be effectively combined to achieve secure remote management. The long-term perspective will enable potential consumers of a better environment with reliable and smart mandates and maintain low-cost consumption.

Author Contributions: Conceptualization, S.S.B. and S.B.S.; methodology, S.B.S.; validation, S.S.B.; investigation, S.B.S.; resources, S.S.B.; writing—original draft preparation, S.B.S.; writing—review and editing, S.S.B.; visualization, S.B.S.; project administration, S.S.B.; funding acquisition, S.S.B. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors acknowledge with thanks the Deanship of Scientific Research (DSR) at King Abdulaziz University (KAU), Jeddah, Saudi Arabia, for the financial support.

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

Appendix A

Table A1. List of Acronyms

SCADA	**SCADA**	Supervisory Control and Data Acquisition	Superv
SGs	**SGs**	Smart Grids	Smart
IED	**IED**	Smart Electronic Device	Smart
IoT	**IoT**	Internet of Things	Interne
ToU	**ToU**	Time of Use	Time o
VPP	**VPP**	Virtual Power Plant	Virtua
VPSs	**VPSs**	Virtual Power Stations	Virtua
MASs	**MASs**	Multi-Agent Systems	Multi-
AMI	**AMI**	Advanced Metering Infrastructure	Advan
DRA	**DRA**	Demand Response Agent	Demar
LSA	**LSA**	Load shifting Agent	Load s
SMA	**SMA**	Meter Agents	Meter
PBNM	**PBNM**	Uniform-Communication-Standard BNM	Unifor
UC	**UC**	User Comfort	User C
AWT	**AWT**	Average Waiting Time	Averag
PAR	**PAR**	Peak-to-Average Ratio	Peak-t
		Scheduling time horizon	Schedu
SPEED	**SPEED**	Sequence Prediction via Enhanced Episode Disco	Sequer
PAg	**PAg**	Smart meter information shows how Prosumer	Smart
FIPA	**FIPA**	Foundation for Intelligent Physical Agents	Founda
JIAC	**JIAC**	Java-based Intelligent Agent Component ware	Java-b
JACK	**JACK**	Intelligent Agents	Intellig
JADEX	**JADEX**	Intelligent Agents	Intellig
SGNM	**SGNM**	Smart Grid Network Management	Smart
MAL	**MAL**	Microgrid Agents Layer	Microg
PAL	**PAL**	Prosumer Agents Layer	Prosur
LLAL	**LLAL**	Loads Layer agents Layer	Loads
SGCM	**SGCM**	SG Configuration Management	SG Co
PMDC	**PMDC**	PM Data Collection	PM Da

SCADA	**SCADA**	Supervisory Control and Data Acquisition	Superv
DDAM	**DDAM**	Device Direct for Access Management	Device
DMSDU	**DMSDU**	DM Smart Devices Upgarding	DM Sm
ICMPS	**ICMPS**	IC Multi Protocol Support	IC Mu
ICWSS	**ICWSS**	IC Web Services Support	IC We
FHECRT	**FHECRT**	FH Event Collection Real Time	FH Ev
FHRA	**FHRA**	FH Root Analysis	FH Ro
PSP	Power Service Provider	Power Service Provider	**SME**
IEA	International Energy Agency	International Energy Agency	**LEP**
ProG	Prosumer Groups	Prosumer Groups	**CHP**
LCOE	Levelized Energy Cost	Levelized Energy Cost	**ESA**
MPS	Market Participation Strategy	Market Participation Strategy	**CPGs**
ProM	Prosumer Market Design	Prosumer Market Design	**ProA**
ProSG	Prosumer smart Grid	Prosumer smart Grid	**ProE**
ProSET	Prosumer Social Economical and Technological	Prosumer Social Economical and Technological	**ProM**
ProGM	Prosumer Goals and Motivations	Prosumer Goals and Motivations	**PMC**
PEC	Prosumer Engagement Class	Prosumer Engagement Class	**ESS**
ProPO	Prosumer Production-Oriented	Prosumer Production-Oriented	**ProC**
EGC	Energy Generation Company	Energy Generation Company	**HESS**
BESS	Building Energy Storage System	Building Energy Storage System	**EVCS**
GEV	Green Electric Vehicle	Green Electric Vehicle	**PSH**
PSB	Prosumer Smart Buildings	Prosumer Smart Buildings	**SEC**
PES	Prices of Electricity Sold	Prices of Electricity Sold	**WPG**
BSSLC	BSS with Large Capacity	BSS with Large Capacity	**HDSM**
DR	Demand Response	Demand Response	**WiMA**
GPRS	General Packet Radio Service	General Packet Radio Service	**MDL**
IEEE	Institute of Electrical and Electronics Engineers	Institute of Electrical and Electronics Engineers	**PLC**
PEM	Prosumer Energy Management	Prosumer Energy Management	**POT**
GA	Genetic Algorithm	Genetic Algorithm	**PMIL**
PGA	Prosumer Genetic Algorithm	Prosumer Genetic Algorithm	**PPSC**
PSO	Particle Swarm Optimization	Particle Swarm Optimization	**IES**
PLP	Prosumer Linear programming	Prosumer Linear programming	**PILP**
DGs	Decentralized Generators	Decentralized Generators	**LP**
PPGL	Prosumer Power Grid Level	Prosumer Power Grid Level	**ICTL**
PML	Prosumer management Level	Prosumer management Level	**PBL**
VPN	Virtual Private Network	Virtual Private Network	**AI**
5G	Fifth-generation wireless	Fifth-generation wireless	**BEM**
BSS	Building Storage System	Building Storage System	**DSOs**
PPP	Point-to-Point Protocol	Point-to-Point Protocol	**X25**
TCP/IP	Transmission Control Protocol/Internet Protocol	Transmission Control Protocol/Internet Protocol	

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