Chapter 28
A Review of Challenges and Solution in Peer-to-Peer Energy Trading of Renewable Sources

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Abstract Peer-to-peer energy trading is the futuristic approach to conserve and trade renewable sources of energy in an economical manner. Peer-to-peer trading leads to a decentralized open free market which benefits both the prosumers who have surplus energy and the consumer with energy deficit. This paper provides a review on the challenges, outcomes, solutions and future research that should be conducted in this area. The various challenges are integrating generation, transmission in a large scale, efficient control of microgrid, developing smart energy meter, complex behavior of prosumers and consumers. The areas of consideration by the previous researchers are game theory, simulation, trading platform, blockchain, optimization and algorithms. We provide a solution by creating a POWERITER cryptocurrency to trade power within local microgrid within blockchain ecosystem for transparency and secured features. It will be a public distributed ledger with proper timestamp consensus. The miners will be rewarded POWERITER tokens to maintain the ledger. This paper will help the researchers for qualitative and quantitative analysis of peer-to-peer energy trading technologies. It is a relatively new topic; there must be a further research to implement this concept in the real-time environment.

Nomenclature

P2P	Peer to peer
Prosumers	People who produce and consume simultaneously
DER	Distributed energy resources
USD	United States Dollar
ESD	Energy storing devices
ICT	Information and communication technology

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28.1 Introduction

Energy sector is the most crucial and important paradigm for infrastructure, economic development and welfare of nations [1]. Traditionally, we depend on the conventional sources of energy such as coal, natural gases, oil, hydro and nuclear power which lead to pollution. The researchers are constantly working on the renewable sources of energy to meet the increasing demand of electricity. According to IBEF report, "by 2022, solar energy is estimated to contribute 114 GW, followed by 67 GW from wind power and 15 GW from biomass and hydropower. The target for renewable energy has been increased to 227 GW by 2022" [2].

The global investment in the power sector as shown in Fig. 28.1 is increasing every year. Since there is a huge investment in the production of electricity, there is monopoly of big corporation. They can manipulate the price according to their connivance which will affect the consumers [3]. There must be a free open market to trade electricity which will lead to competitive pricing [4]. Energy trading benefits the corporation such as increasing the overall efficiency and reducing operating cost.

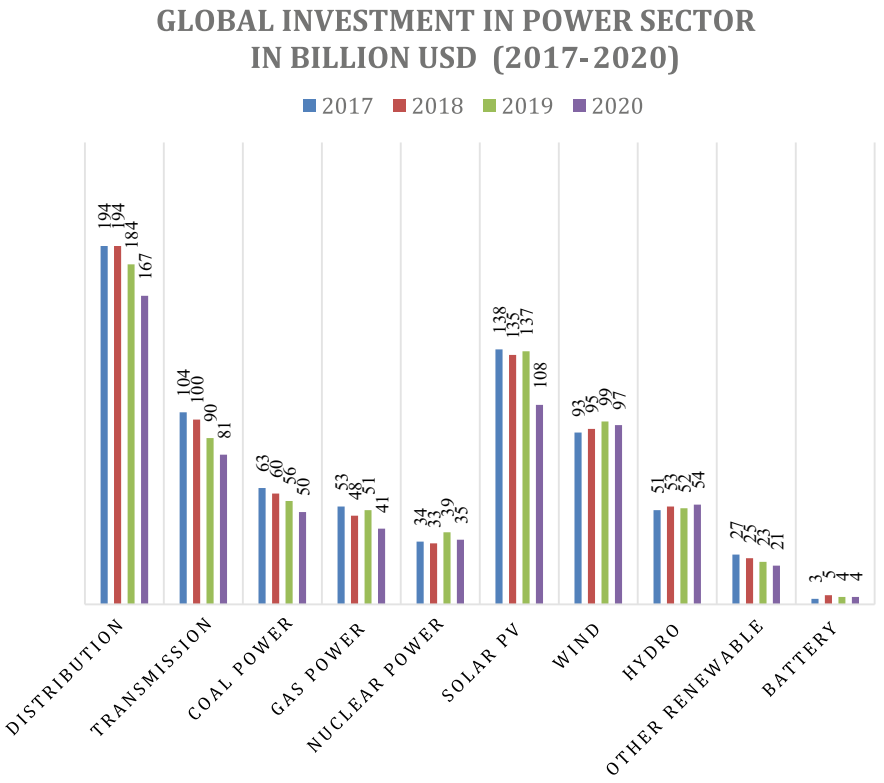

Fig. 28.1 Global investment in power sector

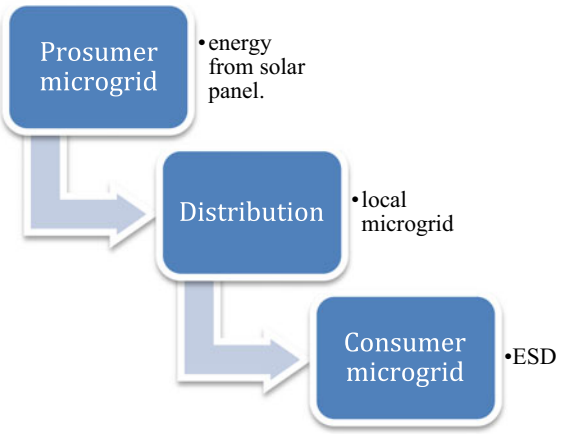

Fig. 28.2 Trading architecture in microgrid

The p2p transfer of electricity is initially possible for prosumers. The generation of electricity is unpredictability and intermittent characteristic of DER [5]. The prosumers have two choices either they can store energy or they can sell it to energy deficit region. The major challenge is to balance the demand and supply effectively [6]. The p2p architecture for transfer to energy has been classified into two types that are trading architecture and optimization model.

28.2 Overview of Peer-to-Peer Architecture

28.2.1 Trading Architecture

The energy trading architecture is the decentralized transfer of power among the peers without involving any single entity. In this, the prosumers generate electricity in a small scale from the rooftop solar panel. When prosumers have surplus of energy, they can sell to consumers in the power grid as given in Fig. 28.2.There are four layers for p2p energy trading, namely business layer, control layer, ICT layer and power grid layer.

28.2.2 Optimization Model

In power systems, consumer demand varies from time to time. During the peak hours, the load can cause frequency deviation which can lead to system failure. The utility companies always balance the demand and supply by load scheduling and price-based optimization.

Load scheduling is achieved through various methods including interruptible load, direct load control (DLR) which allows the power company to manipulate customer appliances and demand side bidding (DSB) where the customer is allowed to prepare a bid.

There are three types of optimization model.

Centrally controlled model

In this model, there is a central controller which connects two local grids. It can optimize the availability in the peak hours. This model is a non-profitable model because the local cannot compete with the utility company pricing. This model can only be implemented by utility companies, and it can be used in rural areas.

Incentive-driven model

The incentive model helps to reduce the transportation cost. The prosumers get incentive to contribute more in an ecosystem. The grid operator coordinates energy sharing by matching supply and demand between sellers and buyers as well as by providing the infrastructure for energy routing. The incentive can be in form of price, auction and smart contracts.

Cooperative-based model

Cooperative model allows a base station having local renewable energy to perform energy trading with the main grid based on coordinated multi-point communication powered by smart grids. "It minimizes the energy cost of cellular systems by providing an algorithm that allows the BS and the smart grid to manage the two-way energy trading. The demand from BS varies over time due to the fluctuation in power generated from renewable energy sources. The proposed model allows the BS to sell electricity to the grid when the power generated from renewable energy sources is excess and to buy power from the grid when the production is low" [6].

28.3 Comparison with Existing Models

We have done the tabulation of the following data from the proposed models [7–11] as given in Table 28.1.

28.4 Challenges in the Proposed Model

Energy management in smart grid

There are many challenges while depending on only renewable or traditional sources of energy. There is a challenge in optimizing peak demand and load dependency. In traditional system, the operating cost is very high [12]. In the renewable system,

Table 28.1 Comparison of the previous proposed models and their results

Project	Country	Year	Objective	Network	Purpose	Result	Comment
Piclo	UK	2014	It was made to help suppliers	National	Business	P2p trading platform	Not for local markets
Vandebron	Netherlands	2014	It benefits suppliers	National	Business	P2p trading platform	Not for local market
Peer energy cloud	Germany	2012	Cloud-based trading platform	Microgrid	Energy network	Cloud-based platform	No discussion on control system
Smart watts	Germany	2011	Optimization of energy supply	Regional	Energy network	Smart meter interface	No discussion on control system
Yeloha and mosaic	USA	2015	Solar sharing network	Regional	Business	Terminated due to funding issues	Not for local market
SonnenCommunity	Germany	2015	Energy trading with storage system	National	Energy network	Online trading platform	Not for local market
Lichtblick swarm energy	Germany	2010	IT market for supplier and consumer	National	Energy network	Many services provided by suppliers	Not for local market
Transactive grid	USA	2015	Microgrid blockchain	Microgrid	Energy network	Automatic trading	Less interactive
Electron	UK	2016	Billing and energy metering	Unknown	Energy network	Not started	Not started

the initial cost is high for households. The transmission is bit complicated, and the system is less efficient.

Security, transparency and transaction time

In traditional system, there is less transparency. The transaction speed is very slowly. The security in a transaction is comprised by utility operators. There are many new technologies which have almost solved the problem like blockchain, smart contract, IoT and AI, cryptocurrencies, etc. [13].

28.5 Proposed Solution

In this model, we are using solar energy for energy management for multiple homes and transfer of electricity from one home to other in case of energy deficiency faced by the neighborhood grids. The primary goals are to maximize financial benefit and reduce the peak of the upstream grid [14]. This way, the proposed manages each home energy hub's energy generation and storage, as well as energy purchase and sale, on two levels: lower and upper level. As the solar panel is set to full power point monitoring (MPPT) so we will connect a DC-DC converter to extract maximum power from the solar panel. This will operate the solar panel at maximum power and will step down to supply the HVDC bus. We have used a bidirectional battery which is beneficial in rainy days [15]. Then, we will connect an inverter that will have input as DC and will convert it to 230 V AC which will be supplied to home. A common AC bus bar to the houses will transfer the energy when needed [16].

28.6 Future Outcomes

The p2p architecture will be the integral part of the power system. There will be highly optimized smart grid which will reduce the operating cost and increase the efficiency. There will be complete dependency on renewable sources of energy to reduce carbon footprint in the ecosystem. The new technologies will create a transparent, secured method of payment [17]. The algorithm of various technologies can be applied in the power system which will helpful in generation, transmission and consumption. As we know now government is promoting e vehicle and there is huge opportunity we can use our system to charge electric cars [18].

28.7 Conclusion

We are designing a business model which will be helpful for both consumer and suppliers. Our POWERITER cryptocurrency can be used in energy sector to trade

surplus power among prosumers. We have free market to have competitive pricing which will benefit the consumers. We have given the incentive to suppliers (miners) to generate POWERITER cryptocurrency and make profit while trading it with fiat currency. Everything is transparent because of public distributed ledger blockchain. We promote the use of renewable energy by giving incentive to both buyer and supplier.

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