COMPUSOFT, An international journal of advanced computer technology, 9(7), July-2020 (Volume-IX, Issue-VII)

Available online at: https://ijact.in

Date of Submission	25/05/2020
Date of Acceptance	15/07/2020
Date of Publication	31/07/2020
Page numbers	3743-3748 (6 Pages)

ISSN:2320-0790

COMPUSOFT
An International Journal of Advanced Computer Technology

BLOCKCHAIN-BASED SMART ENERGY TRADING: MOTIVATIONS AND CHALLENGES

Ahmad Amini[1], Norziana Jamil[1,2], Farah Aqilah Bohani[2]

[1]College of Computing and Informatics, Universiti Tenaga Nasional,
Jalan IKRAM-UNITEN, Kajang, Selangor, Malaysia.
[2]Institute of Energy Infrastructure, Universiti Tenaga Nasional,
Jalan IKRAM-UNITEN, Kajang, Selangor, Malaysia.

Abstract: The growing population and high demand of renewable energy leads to a decentralized solution to trade energy smartly. In an innovative energy market, consumers and prosumers are able to trade green energy locally and directly to balance the generation and consumption through decentralized community. In this paper, we present a comprehensive review of existing energy trading systems, their motivations and challenges. For this reason, new ICT technologies are investigated to consider their incredible affections on data transparency, energy trading and how energy consumer and producers are connected intelligently. The similarities, differences and challenges in different energy trading projects are identified. The comparison analysis leads us to analyze the future scenario of energy trading that can offer high level of data transparency, low trading cost and less trading time.

Keywords: blockchain, energy trading, smart energy, renewable energy, energy market

I. INTRODUCTION

In recent years by growing population the world's energy demands have increased. In this situation, old and non-renewable energy sources such as oil, coal and gas are not able to support global energy demands. Moreover, those types of non-renewable energies become more expensive and not environmental friendly. These issues are the main motivations of developing various types of Renewable Energy Sources (RES) (e.g. solar and wind turbines). The integration of traditional energy resources and RES generalize a massive amount of energy data such as metering data that require digitalized energy system to manage and analysis big data. The Information and Communication Technology (ICT), Internet of Things (IOT), communication networks and data analytic constitute a catalyst towards conceptualizing and generating new energy solutions[1]. Therefore, these technologies are the main rapidly grown solutions for energy management and supplement stability, communication energy consumer and producer intelligently, share smart meter data through network and share it with consumer to improve data transparency, maintain the balance between demand and supply dynamically, and provide high level of security and privacy. Peer-to-Peer (P2P) energy trading as an online service based on ICT is one of the most important developments of power systems. The term p2p commonly associated with file and data sharing that is referred to the larger phenomenon of collaborative activities between users online and specially between consumer and producer in energy sector [2]. The development of sustainable energy resources and technologies is a valuable expanded area to share energy data through P2P network. On the other hand, P2P trading enables everyone to engage in energy exchange without relying on a central utility company[3]. The P2P as a distributed energy trading brings various benefits to both consumer and producers such as reduce power outage, provide alternative energy resources, reduce operation cost and save energy bills, improve supply stability and reliability, increase efficiency of trading energy over network, enable everyone to engage in energy trading, and create competitive energy market without centralized utility company.

The demand curve is an optimization issue where balance is not matched between supply and demand in P2P energy trading[4]. The lack of supply and demand management faces all energy participates with technical challenges such as high pricing, low interaction, no optimized adaptive decision making, and no dynamic operation[5]. Security and privacy are other issues which can break data integrity, and confidentiality. Security and privacy objectives in automation network (P2P) aims to provide transaction safety, equipment and power line protection and system operation [6]. In some cases such as Plug-in Electric Vehicles (PEVs), entities are locating dynamically in P2P energy trading network that cause user authentication issues. During roaming, charging external and untrusted entities are involve and hence the user sensitive information should be protected by proper authentication mechanisms[7]. In prior published research, different solutions are proposed to address those issues such as Internet of Things (IoT), cloud computing and Blockchain technology. In the IoT paradigm all the objects that are surrounded us will be equipped with sensors network technologies to embed information and communication in the network environment[8]. Adoption of IoT technology in smart P2P network enables data exchange between devices remotely to improve efficiency of data capturing and reduce human interaction. Additionally, adoption of smart devices in IoT creates advance management system to match the balance between devices. Cloud computing as virtual infrastructure integrates smart devices, storages, client delivery and analytic tools to enable cost effective end-to-end service to access on demand data everywhere in anytime. Finally, Blockchain as an emerging ICT technology offers new opportunities for smart energy trading such as data transparency, lower transaction cost, massive integration of renewable energies, optimize demand management, and provide high security standard to store and transfer data between network entities. Blockchain in energy sector is a novel approach that combines smart contracts along with the IoT devices to enable peer-to-peer market where smart devices can buy and sell energy automatically according to the user predefine criteria [9]. However, those discussed significant solutions and technologies could result some practical challenges such as lower transaction and higher latencies, complicated process to maintain privacy, high risk on transaction censorship, information redundancy, security of smart contract, and modifying and coordinating all cooperated parties (cloud computing, IOT, Blockchain).

In this paper, comprehensive review of challenges and opportunities of current smart energy trading systems are investigated (Section 2); then existing projects with their objectives have been listed and compared to find out potential benefits and challenges of integrating extensive ICT technologies and smart energy trading (Section 3). In the next section (Section 4) paper discusses future scenario of smart energy trading and promises of Blockchain technology to address potential challenges. Finally, conclusion is drawn (Section 5).

II. Literature Review

In the literature, smart energy trading system for renewable energies are investigated and compared to find out advantages and address the most significant challenges. Verma at al.[10]proposed energy trading Blockchain based peer-to-peer energy trading between multiple micro-grids to maximize the usage of renewable energy trading. The main motivation of this research is the lack of regulated and secure energy trading. The project named “EnerPort” involves implementing Blockchain technology with smart metering and new software tool for simulating electricity distribution networks and Blockchain based P2P trading. This project aims to provide scalable demonstration of Blockchain based P2P trading in distributed grid and address key challenges of hardware and software requirements, policies and market issues.

The aim of the research presented by Mengel kamp at all[11] is trading energy in Local Energy Market (LEM) to balance supply and demand between consumers and prosumers. This research provides preliminary analysis of using Blockchain technology as a main ICT for decentralized LEM to control transactions costs. Thakur at al [12] developed a Blockchain based distributed algorithm for coalition formation of energy trading among Micro Grids (MG) to mitigate security, privacy, synchronization, robustness, trust, and scalability issues. Furthermore, experimental evaluation has shown distributed based algorithm generate more optimized coalition and scalable structure than a centralized one. The Internet of Thing (IoT) is proposed by Zhiyi at al [13] to enable fine-grained observability and constructability of Active Distributed Network (ADN) in decentralized micro grids network. The Blockchain technology suggested addressing potential cybersecurity issues in IoT-enabled ADN, and creating secure, scalable, and efficient energy management framework. On the other hand, Blockchain and IoT technologies are employed to secure MGs network and consider trust-worthy entities that are participated in decentralized network. Misra at all [14]proposed a new algorithm (ENTRUST) for real time energy exchange among customers and grid. ENTRUST includes optimization process that enables expectation of the real time pricing and another part for grid that executes the expectation of real time demand from customers. Furthermore, they model real time energy trading in smart grid to optimize demand and price from both customer and grid perspectives. Reference [15] is focused in energy trading in distributed network between participants known as aggregators. A three-tiered architecture including aggregator scheduling, trading optimization, and micro-grid balancing presented to motivate the efficient utilization of distributed energy resources regardless of their location. This methodology improves the utilization of renewable energies, and mitigates the unavailability of centralized dispatching. Reference[16] addressed challenges of Demand Side Management (DSM) coordinated with P2P energy trading in cloud based energy trading model for smart homes. This study has been developed for centralized architecture and considers the renewable energy resources and home storages as Distributed Energy Resources (DER). This cloud based infrastructure is suitable to apply to process huge smart grid data and minimize the energy cost from consumers' perspective.

III. COMPARISON OF PROJECTS

The comparison of above discussed researches has been summarized in Table I. According to our comparison, different researches with variety of objectives have aimed to optimize energy trading management by employing extensive ICT technologies such as cloud computing, IoT, and Blockchain. The P2P Energy trading based on ICT leads organizations to maximize the potential benefits of peers' competition, reduce electricity cost, match the balance between supply and demand, reduce trading time, reduce energy lose, mitigate security issues, secure communications to trade energy, automate energy management, optimize energy management reliability, and develop smart energy trading. As a result, most of studies focus on decentralized techniques to integrate massive amount of renewable resources in an efficient manner rather than in a centralized manner. The coordination of decentralized technology and integration with ICT technologies offer effective solutions to optimize energy trading performance but it also face energy trading leaders with enormous challenges. For instance implementing of IoT solution in cloud-based distribution network to save, retrieve, and process big data often criticize for single point of failure, poor scalability, privacy and security issues and subject to wide variety of other cyber-attacks. As shown in the comparison table, Blockchain has been offered as the most promising technology to distribute energy through P2P network with high level of security and privacy. Beside all the advantages of Blockchain, still number of concerns have existed to take into consideration; enforce MGs to update their software adequately to prevent system from executing malwares, protect IoT devices from cyber-attacks and Trojans, monitor and update MGs with new stored patches on Blockchain, secure smart contract programming, optimize scalability and real time trading on Blockchain, consider the complexity of Blockchain as a major barrier and etc.

IV. OBSERVATION OF THE TREND OF SMART ENERGY TRADING

The smart energy trading relies on different factors such as verifying and certifying renewable energy resources, making greater data transparency, guarantying origin of renewable resources and providing easier access to the market to participate. The Renewable Energy Certificate (REC) is a unit of green energy that acts as tracking and accounting sustainable energy that is generated from certified renewable sources. In other words, the REC is a block of information and measuring factors of 1 MWh electricity to minimize carbon footprints, provide free access to data and analyse them as well. The Blockchain technology facilitates network participates to access RECs and determine the origin of renewable energy through comprehensive platform. Moreover, engaging REC and Blockchain technology cause better data transparency, lower cost, and less trading time through trusted relationship between all participates. The integration of green energy and Blockchain is called Greenchain. As a result the Greenchain innovation aims to cover some challenges of current solutions such as securing transactions, ensuring consistence of energy suppliers, real time trading, evaluating trust, security and privacy between MGs, tracking and monitoring MGs, optimizing energy storages, and processing IoT data intelligently.

Table I: Comparison of Energy Trading Systems

Project reference	Start year	Objectives	ICT					Motivations	Challenges
						Network			
			CC	IoT	BC	Decentralized	Centralized		
[10]	2018	• Provide scalable demonstration of Blockchain based P2P trading • Address key challenges of hardware and software requirements		✓	✓	✓		• Maximize the overall valuation of network peers cooperation. • Maximize peers' utility from participating in P2P energy trading	• Securing the transactions • Ensuring consistence supply of energy
[11]	2017	• Using Blockchain in local energy market • Simulating of Blockchain based energy trading.			✓	✓		• Reduce electricity cost for LEM participants. • Match supply and demand.	• Blockchain challenges such as scalability and real time trading • Regulatory changes
[12]	2018	• Develop BC based on distributed algorithm for coalition among MGs • Develop secure and scalable platform to store and transfer records			✓	✓		• Optimize scalability and coalition to ensure MGs correctly executes. • Reduce the waiting time for MGs to trade energy with other micro grids • Reduce energy loss due to long transmission. • Mitigate security issues	• Most of centralized approaches are not robust technique. • The lack of trust evaluation among MGs allows a malicious MG to change the result of coalition structure • The centralized approaches are not scalable. • The lack of security and privacy in energy trading between MGs
[13]	2018	• Propose a secure, scalable and efficient energy management framework to ensure integrity and privacy of	✓	✓	✓	✓		• Optimize automation the AND energy management in efficient, scalable and cyber secure manner. • Secure communication among	• Meeting involving cyber-security requirement in ADN network. • Implement intelligent IoT lead to comprehensive operational

		decision making process						IoT devices by introducing BC technology.	challenges. • Communication among MGs subject to wide variety of cyberattacks.
[14]	2015	• Propose game-theoretic energy management to deal with incompleteness of the received energy demand. • Minimize customers' energy consumption cost					✓	• Optimize real-time energy trading. • Establish cost effective and reliable energy management in a smart grid.	• Use centralized coalition algorithm is not a robust technique.
[15]	2018	• Propose energy trading in the distribution network market among different participants. • Meet the local energy demand by controlling and coordinating DERs .				✓		• Reduce marginal cost of distributed generation. • Maximize profit through addressing dynamic guiding price during three-tiered optimization • Optimize the DERs configuration	• Monitor and control MGs coordinating to exchange energy • Realize the global optimization of energy storage. • Estimate the marginal cost of distributed generator.
[16]	2017	Lack of secure, regulated and flexible market for energy trading			✓	✓		• Design simulation of Blockchain transactions and electricity networks. • Develop a smart home bench demonstration • Integrate of Blockchain and open source distribution system	• Ensure a consistence supply of energy • Securing the transactions • Revenue distribution

V. Conclusion

There are a number of studies on smart P2P trading with different objectives to optimize energy trading among suppliers, producers and customers. The details of those projects included objectives, motivations, challenges and involved technologies have been listed, compared, and discussed in this paper. Different ICT technologies have been employed to maximize potential benefits of real time energy trading, reduce the cost of transferring energy, optimize energy transferring time, and match balance between supply and demand. Most of the recent studies focus on decentralized and integrate it with Blockchain technology in efficient manner to optimize energy trading performance. Accordingly, most of offered solutions could be considered as optimized solutions with some remain challenges. The Greenchain is considering as very promising solution which can optimize decentralized P2P trading with tackling most of existing challenges.

Acknowledgement

This research is supported by Uniten UNIIG Grant with a Project Code J510050820.

References

[1] Marinakis, V., et al., 2018. From big data to smart energy services: An application for intelligent energy management. Future Generation Computer Systems.

[2] Hamari, J., Sjöklint, M. and Ukkonen, A. 2016. The sharing economy: Why people participate in collaborative consumption. Journal of the association for information science and technology. 67(9), 2047-2059.

[3] Abdella, J. and Shuaib, K. 2018. Peer to peer distributed energy trading in smart grids: A survey. Energies. 11(6), 1560.

[4] Malik, A. and Ravishankar,J. 2016. A review of demand response techniques in smart grids in IEEE Electrical Power and Energy Conference (EPEC).

[5] Wang, H., et al., 2016. Reinforcement learning in energy trading game among smart microgrids. IEEE Transactions on Industrial Electronics. 63(8), 5109-5119.

[6] Haq, E.U., et al., 2017. Smart grid security: threats and solutions in 13th International Conference on Semantics, Knowledge and Grids (SKG).

[7] Shuaib, K., et al., 2017. Secure plug-in electric vehicle (PEV) charging in a smart grid network. Energies. 10(7), 1024.

[8] Gubbi, J., et al., 2013. Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems. 29(7), 1645-1660.

[9] Christidis, K. and Devetsikiotis, M. 2016. Blockchains and smart contracts for the internet of things. IEEE Access. 4, 2292-2303.

[10] Verma, P., et al., 2018. EnerPort: Irish Blockchain project for peer-to-peer energy trading. Energy Informatics. 1(1), 14.

[11] Mengelkamp, E., et al., 2018. A blockchain-based smart grid: towards sustainable local energy markets. Computer Science-Research and Development. 33(1-2), 207-214.

[12] Thakur, S. and Breslin, J.G. 2018. Peer to peer energy trade among microgrids using blockchain based distributed coalition formation method. Technology and Economics of Smart Grids and Sustainable Energy. 3(1), 5.

[13] Li, Z., Shahidehpour, M., and Liu, X. 2018. Cyber-secure decentralized energy management for IoT-enabled active distribution networks. Journal of Modern Power Systems and Clean Energy. 6(5), 900-917.

[14] Misra, S., et al., 2016. ENTRUST: Energy trading under uncertainty in smart grid systems. Computer Networks. 110, 232-242.

[15] Liu, Y., et al., 2018. Dynamic pricing for decentralized energy trading in micro-grids. Applied energy. 228, 689-699.

[16] Alam, M.R., St-Hilaire, M. and Kunz, T. 2017. An optimal P2P energy trading model for smart homes in the smart grid. Energy Efficiency. 10(6), 1475-1493.