International Conference on Applied Energy 2020
Dec 1-10, 2020, Bangkok/Virture
Paper ID: 139

An overview of peer-to-peer energy trading from the "business model canvas" perspective

Xianming Ye, Lijun Zhang, Xiaohua Xia

Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria 0002, South Africa

ABSTRACT

Existing research has active contributions to the P2P trading framework development, such as cost minimisation for distributed power generation, local supply and demand balancing, prosumer engagement, pricing model development, and trading security, etc. These technical developments actively contribute to the P2P energy trading infrastructure development. In order to enhance the market penetration of the P2P energy trading concept, we need suitable business models for different energy markets across the globe based on the available technical infrastructures for the P2P energy trading. For this purpose, this study offers a novel overview of the P2P energy trading from the existing literature based on a business model canvas strategy. With the support of the business model canvas, we analyse the existing P2P energy trading literature in terms of nine business model development elements, namely customer segments, customer relationships, key partners, value proposition, channels, key resources, key activities, cost structure, and revenue streams. Our study contributes to the P2P energy business model development, which also reveals new research areas for the P2P energy trading.
Keywords: energy management, P2P energy trading, peer-to-peer energy sharing, prosumers

1 INTRODUCTION

The ever-increasing energy prices and the continuously decreasing feed in tariffs of the power from distributed resource generation call for a inevitable transition of the existing energy market. One of the most popular evolutions in the energy market is the peer to peer (P2P) energy trading. The P2P energy trading is a part of the sharing economy, which offers renewable energy prosumers an opportunity to trade their surplus power generated from distributed energy resources freely to the neighbourhood. When looking into the business potentials of the P2P energy trading framework, it exhibits following remarkable features: 1) it satisfies a new set of needs that customers previously do not perceive because there was no similar offering; 2) it improves product or service performance in terms of power supply and delivery; 3) it supplies energy at a lower price; 4) it helps customer reduce costs to creat value; 5) it reduces risks of power outage; 6) it enhances local accessibility; and 7) it provides a more convenient way of energy supply and trading. Due to these advangeous characteristics of the P2P energy trading, it is widely believed that the P2P energy trading framework would become the next-generation energy trading solutions in the future energy market, which is able to bring multilateral benefits to various potential participants in the P2P energy trading network, such as public entities, independent power producers, energy service companies in the private sector, and electricity retailers.

The concept of the P2P energy trading has received considerable research attention in recent years. A state of the art analysis for P2P energy trading has commented in [1] that the key aspects of the P2P energy trading focus on the market design, trading platform development, physical and communication infrastructures, social science perspectives, and policy development aspects. Another overview of the P2P energy trading in electricity networks has provided insightful overview about the P2P energy trading in terms of the network elements, market structure, and technical approaches [2]. The study [2] also recommends a number of future research directions for P2P energy trading, namely network charge identification, ancillary sevice to the grid, etc.

The existing literature review studies well summarised the technical infrastructure developments for the P2P energy trading. In order to enhance the market penetration of the P2P energy trading framework, this study provides a novel overview on the P2P energy trading from the P2P business model development point of view. Our study is unique in following aspects. Firstly, this study applies the "business model canvas" framework [3] to support the P2P energy trading business model innovation. Secondly, this study looks into the values chain of the P2P business, namely value proposition, value creation and delivery, and value capture. Along with the value chain, we further analyse the nine essential generic business model development elements such as customer segments, customer relationships, key partners, value proposition, channels, key resources, key activities, cost structure, and revenue streams. Based on our review study, we reveal several potential research areas for

the P2P energy trading business model developments.

2 THE BUSINESS MODEL CANVAS

The business model canvas originated from [3] proposes nine business model elements as shown in Figure 1. This study plans to discuss the applicability of the business model canval approach for the P2P energy trading, and categorises the existing literature on P2P energy trading in these nine business model elements.

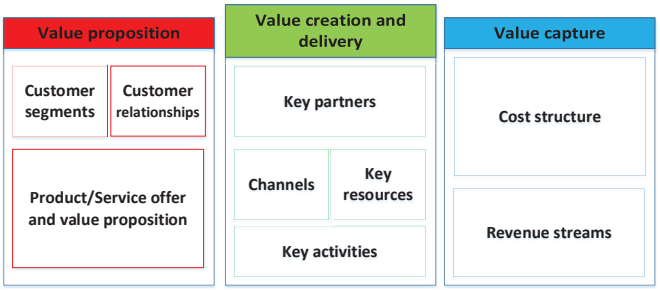

Fig. 1. Business model canvas [3].

3 P2P ENERGY TRADING VALUE PROPOSITION

3.1 Customer segments and customer relationships

The customer segments refer to the different groups of people or organizations to be served. As it is still unclear who are going to be the P2P energy trading service providers, we extend our discussion on the customer segments to both potential P2P energy trading service providers and receivers. A typical P2P energy trading framework is illustrated in Figure 2.

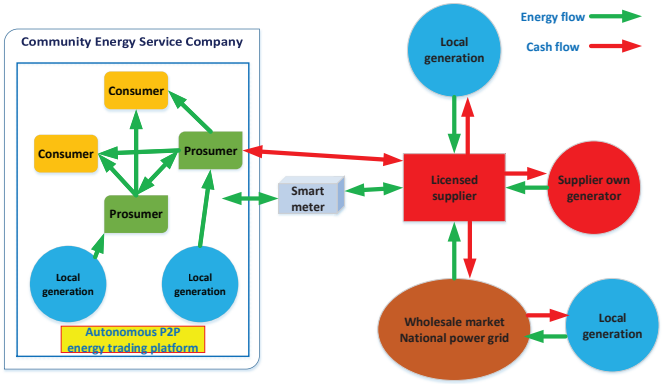

Fig. 2. An illustration of the P2P energy trading.

The key participants and their roles and responsibilities for the P2P energy trading are mentioned in the literature. For instance, the study [4] proposes a P2P energy trading framework that includes a market operator and treats the utility grid as a prosumer. Other research work has offered some initial discussions about the features of the P2P energy trading participants. For instance, the study [5] has segmented the prosumers into "green prosumer", "philanthropic prosumer", and a "low-income household", which also comments that prosumers may have different preferences such as to obtain the best financial return, or to obtain energy from lcoal sources or particular generation technologies; or to trade energy with particular subscribers such as friends, relatives, low income residents, and community organisations. The study [6] discusses the objectives of the consumers and prosumers in terms of energy trading, fairness in trading, privacy and security of data, higher incentive, and freedom of selection of energy suppliers/buyers. Discussions on the objectives and preferences of the prosumers and consumers in the P2P energy trading network will facilitate the customer segments. However, further studies are still expected on the customer segments in terms of 1) minimum power generation capacity requirements for a prosumer; and 2) whether a licence or a legal registration is required for a prosumer prior to performing the P2P energy trading, etc.

The customer relationships refer to the types of relationships between the service/product provider to each customer segments. Existing research contributions to the customer relationships mainly lie in two major categories, namely the relationships among the prosumers and the relationships between P2P energy trading and the existing markets. Game relationships have been discussed in [7], a non-cooperative game model and Stackelberg game model are emplyed to separately analyze gaming relatioship among sellers, and between sellers and buyers. Future research about the customer relationships in the P2P enegy trading network can be carried out in the following areas: 1) the relationships between different customer segments; 2) The relationship between the multiple participants such as the community energy service company, the licenced supplier, and the national grid, etc.

3.2 Product and service

The value proposition refers to the products and services that create value for a specific customer segment. In the P2P energy trading network, the service providers can trade energy products in various forms such as electricity, gas, or heat, etc. In [1], it offers an interesting summary of existing electricity products such as time of use (ToU) electricity, real-time pricing electricity, etc., recent proposed energy for P2P energy trading such as green energy, subsidized energy, Eucidean distance based electricty, etc., and comments that future electricty producted shall ensure power quality and supply reliability. The energy product is the core of P2P energy trading. Supporting research areas can be conducted in following areas: 1) Technical requirements on the prosumers shall be made available to ensure they can offer high quality energy product reliably; 2) flexible energy storage and power delivery solutions to be adopted to enhance the service delivery of energy product in the P2P network; and 3) standardisation of energy product versus price when multiple energy products are offered in the same P2P energy trading network.

In the P2P energy trading network, the following ser-

vices are believed to create value to the customers. Firstly, the digital transaction of energy and its related payment may incur cybersecurity issues. Several existing P2P energy trading studies have concerned about the user privacy and security such as identification, location, etc. when using technology. The study [8] has summarised a series of potential privacy and security risk mitigation approaches by using consorium blockchains, bitcoin, applying an effficient and privacy preserving matching, or enabling an authentification process before the energy trading. In [9], it discusses the prosumers' private information such as preferences, their targeting demand and self generation capacity as such information may influence the trading price should game theoretical approaches are applied to determine the internal trading prices. Further research contribution can be made in several aspects: 1) to use minimum user information for the implementation of the P2P energy trading; 2) to preserve and protect user's private information during the transaction; and 3) to protect the robustness of the P2P energy trading system under cyber-physical attacks.

The second type of service for P2P energy trading is the trading performance evaluation servcies. In [10], performance evaluation is conducted based on both economic indices, namely the cost savings, increased income, and overall benefits, and technical indices such as energy balance and power flatness. In [11], the assessment matrices are self consumption, self sufficiency, cost of community energy, energy bills of individual customers, and participation willingness indices.

The third type of service for P2P energy trading is the optimal power flolw management under various internal price mechanisms and bidding strategies. This area actually attracts massive research activities. For instance, the study [12] considered a unified optimal battery sizing and power flow management in the P2P energy trading network. Due to additional energy geneartion units, energy storage units, and new developments on the internal pricing model, it is expected that the power flow management related research will continuously be advanced.

4 P2P ENERGY TRADING VALUE CREATION AND DELIVERY

4.1 Key partnerships, resources, and activities

The key resources refer to the most important assets required to make a business model work. The key resources can be classified into physical, financial, intellectual, or human resources. The key activities describe the most important things a company must do to operate its business model. The key activities can be categorised as production, addressing customer needs, and design and build the P2P energy trading network. The key activities bridge the business model elements of the value proposition and channels for service delivery. Readers can refer to the Section 3.2 and Section 4.2 for details. The key partnerships are the network of suppliers and partners that make the business model work. For the P2P energy trading, the key partnership can be illustrated by Figure 2. The basic form of parnership is designed to optimize the allocation of resources and activities. Relevant P2P energy trading participants can either form strategic alliances as non-competitors or competitors.

4.2 Channels

The channels refer to the way that a product or a piece of service can be delivered to the customer. For P2P energy trading, the potential business channel development can be focused on the following areas, namely raise awareness of the value proposition in terms of product and service, trading, service delivery and post-purchase customer support. In this section, our review will focus on trading and service delivery.

The P2P energy trading and service delivery refers to the technical solutions for local energy trading by wireless power transfer, existing power delivery network, or battery energy storage systems. In [8], the authors considered P2P energy sharing in four different types of mobile network applications, which provides a summary of the energy sharing technologies such as wireless power transfer. In [13], the impact of the P2P energy trading on the power losses in grid-tied networks has been investigated, in which the network loss due to P2P energy trading was traced.

The P2P energy trading and service delivery requires technical support of the P2P energy trading network, physical and IT infrastructures. Many existing studies have proposed various P2P energy trading platforms. The study [10] proposes a P2P energy trading framework for the energy sharing coordinator and prosumers, which also shares a P2P market internal trading process. Ref. [9] presents a radial network, in which the prosumers can trade energy with neighbours inside their local community. The study [14] has discussed three types of P2P energy network, namely microgrid to microgrid energy trading, intra-microgrid P2P energy trading, and peer to microgrid energy trading.

5 P2P ENERGY TRADING VALUE CAPATURE

The value capture for P2P energy trading consists of two business model elements, i.e., the cost structure and revenue streams.

5.1 Revenue streams

Revenue streams represent the profit generates from each customer segment. The revenue streams can be realised by one time payment and/or recurring revenue from offering ongoing P2P energy trading services. Existing studies have not paid sufficient attention to discuss the renenue streams in the P2P energy trading network. The authors are anticipating that the energy might become a tradable product like the mobile data and airtime, where customers can have flexible option to join or quit a specific P2P energy trading network, and also select the most cost-effective way for their "energy bundle" either by once off transaction or a monthly subscription fee.

5.2 Cost structure

The cost structure describes all cost incurred from the key resources, key activities, and key parnerships of a business. The cost structure includes both the fixed cost and variable cost. The internal trading pricing mechnisms is one of the most active research topics for the P2P energy trading. In the literature, several price mechanisms have been proposed such as the double auction principles [6, 15], the supply and demand ratio approach, the mid market rate, etc. The double auction priciples are widely adopted to design the internal price models. The study [16] considers the discriminatory and uniform k double auction, and impacts of different bidding strategies on the economic effciencies of the P2P transactive energy market are also studied. A number of studies has applied the supply and demand ratio to decide the internal trading price [4, 17, 18]. Additionally, there are also other P2P internal energy trading price models in the literature. For instance, a willingness-to-pay approach is developed to decide the internal trading prices in [4]. The studies [19] formulate the electrcity cost as a quadratic function of the power set-point.

6 CONCLUSIONS

This study provides an overview of the existing P2P energy trading research development from the "business model canvas" perspective. The business model canvas approach well facilitates the future development of the P2P energy trading business model. We identified that considerable research potentials to develop the customer segments, prioritise the customer relationships, expand the existing products and services, enhance the product and service delivery channels, and improve the business revenue streams by calibrating the cost structures of various P2P energy trading related products and services.

REFERENCES

[1] Zhou, Y., Wu, J., Long, C., and Ming, W., 2020. "State-of-the-art analysis and perspectives for peer-to-peer energy trading". *Engineering*.

[2] Tushar, W., Saha, T. K., Yuen, C., Smith, D., and Poor, H. V., 2020. "Peer-to-peer trading in electricity networks: an overview". *IEEE Transactions on Smart Grid*.

[3] Osterwalder, A., and Pigneur, Y., 2010. *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons.

[4] Basnet, A., and Zhong, J., 2020. "Integrating gas energy storage system in a peer-to-peer community energy market for enhanced operation". *International Journal of Electrical Power & Energy Systems, 118*, p. 105789.

[5] Morstyn, T., and McCulloch, M. D., 2018. "Multiclass energy management for peer-to-peer energy trading driven by prosumer preferences". *IEEE Transactions on Power Systems, 34*(5), pp. 4005–4014.

[6] Amin, W., Huang, Q., Umer, K., Zhang, Z., Afzal, M., Khan, A. A., and Ahmed, S. A., 2020. "A motivational game-theoretic approach for peer-to-peer energy trading in islanded and grid-connected microgrid". *International Journal of Electrical Power & Energy Systems, 123*, p. 106307.

[7] Liu, H., Li, J., Ge, S., He, X., Li, F., and Gu, C., 2020. "Distributed day-ahead peer-to-peer trading for multi-microgrid systems in active distribution networks". *IEEE Access, 8*, pp. 66961–66976.

[8] Dhungana, A., and Bulut, E., 2020. "Peer-to-peer energy sharing in mobile networks: Applications, challenges, and open problems". *Ad Hoc Networks, 97*, p. 102029.

[9] Le Cadre, H., Jacquot, P., Wan, C., and Alasseur, C., 2020. "Peer-to-peer electricity market analysis: From variational to generalized nash equilibrium". *European Journal of Operational Research, 282*(2), pp. 753–771.

[10] Zhang, B., Du, Y., Lim, E. G., Jiang, L., and Yan, K., 2019. "Design and Simulation of Peer-to-Peer Energy Trading Framework with Dynamic Electricity Price". In 2019 29th Australasian Universities Power Engineering Conference (AUPEC), IEEE, pp. 1–6.

[11] Long, C., Wu, J., Zhou, Y., and Jenkins, N., 2018. "Peer-to-peer energy sharing through a two-stage aggregated battery control in a community microgrid". *Applied energy, 226*, pp. 261–276.

[12] Rodrigues, D. L., Ye, X., Xia, X., and Zhu, B., 2020. "Battery energy storage sizing optimisation for different ownership structures in a peer-to-peer energy sharing community". *Applied Energy, 262*, p. 114498.

[13] Azim, M. I., Tushar, W., and Saha, T. K., 2020. "Investigating the impact of P2P trading on power losses in grid-connected networks with prosumers". *Applied Energy, 263*, p. 114687.

[14] Tushar, W., Saha, T. K., Yuen, C., Morstyn, T., McCulloch, M. D., Poor, H. V., and Wood, K. L., 2019. "A motivational game-theoretic approach for peer-to-peer energy trading in the smart grid". *Applied Energy, 243*, pp. 10–20.

[15] Wang, Z., Yu, X., Mu, Y., and Jia, H., 2020. "A distributed peer-to-peer energy transaction method for diversified prosumers in urban community microgrid system". *Applied Energy, 260*, p. 114327.

[16] Lin, J., Pipattanasomporn, M., and Rahman, S., 2019. "Comparative analysis of auction mechanisms and bidding strategies for P2P solar transactive energy markets". *Applied Energy, 255*, p. 113687.

[17] Liu, N., Yu, X., Wang, C., Li, C., Ma, L., and Lei, J., 2017. "Energy-sharing model with price-based demand response for microgrids of peer-to-peer prosumers". *IEEE Transactions on Power Systems, 32*(5), pp. 3569–3583.

[18] Long, C., Zhou, Y., and Wu, J., 2019. "A game theoretic approach for peer to peer energy trading". *Energy Procedia, 159*, pp. 454–459.

[19] Sorin, E., Bobo, L., and Pinson, P., 2018. "Consensus-based approach to peer-to-peer electricity markets with product differentiation". *IEEE Transactions on Power Systems, 34*(2), pp. 994–1004.