Proc. of International Conference on Artificial Intelligence, Computer, Data Sciences and Applications (ACDSA 2026)
5-7 February 2026, Boracay Island-Philippines

2026 International Conference on Artificial Intelligence, Computer, Data Sciences and Applications (ACDSA) | 979-8-3315-7191-7/26/$31.00 ©2026 IEEE | DOI: 10.1109/ACDSA67686.2026.11467723

Decentralized Peer-to-Peer Electricity Trading Simulation Dashboard

Asrani Lit
Faculty of Engineering
Universiti Malaysia Sarawak (UNIMAS)
Kota Samarahan, Malaysia
lasrani@unimas.my

Nazreen Junaidi
Faculty of Engineering
Universiti Malaysia Sarawak (UNIMAS)
Kota Samarahan, Malaysia
jnazreen@unimas.my

Shirley Rufus
Faculty of Engineering
Universiti Malaysia Sarawak (UNIMAS)
Kota Samarahan, Malaysia
rshirley@unimas.my

Yanuar Zulardiansyah Arief
Faculty of Engineering
Universiti Malaysia Sarawak (UNIMAS)
Kota Samarahan, Malaysia
ayzulardiansyah@unimas.my

Sharifah Masniah Wan Masra
Faculty of Engineering
Universiti Malaysia Sarawak (UNIMAS)
Kota Samarahan, Malaysia
wmmasnia@unimas.my

Mohd Zamri Che Wanik
Qatar Environment &
Energy Research Institute
Hamad Bin Khalifa University
mwanik@hbku.edu.qa

***Abstract*—Peer-to-Peer (P2P) electricity trading has emerged as a key enabler for decentralized energy systems, allowing prosumers with distributed energy resources such as solar photovoltaic (PV) systems and electric vehicles (EVs) to buy and sell electricity directly. This paper presents a lightweight, interactive simulation dashboard for P2P electricity trading, developed using the Streamlit framework. The system models energy generation, demand patterns, dynamic pricing, and matching algorithms to emulate a residential P2P microgrid. Prosumers and consumers are represented with distinct profiles including solar homes, EV homes, hybrid solar-EV homes, and traditional consumers allowing visualization of energy flows and market activity. The dashboard provides real-time charts, automated trading logs, and a simplified market-clearing mechanism, making it suitable for teaching, prototyping, and community microgrid feasibility studies. Results demonstrate the capability of the simulation to model heterogeneous household interactions and visualize trade behavior across daily cycles. This tool offers a foundation for further work incorporating battery storage, blockchain smart contracts, and real-world sensor data.**

Keywords—Peer-to-Peer Energy Trading, Microgrid, Distributed Energy Resources, Renewable Energy, Electric Vehicles.

I. INTRODUCTION

The rise of distributed energy resources (DERs), such as rooftop solar photovoltaic systems and electric vehicles, is reshaping modern electricity distribution. Traditional top-down power delivery is progressively evolving toward prosumer-centric models [1]. P2P energy trading enables users to buy and sell electricity directly within localized networks, increasing renewable energy utilization and reducing dependency on centralized utilities [2]–[4]. Real-world deployments such as the Brooklyn Microgrid project [5] and emerging blockchain-enabled platforms [6]–[8] highlight the growing adoption of community-driven energy sharing models. P2P electricity markets contribute to grid resilience, cost savings, and carbon reduction, especially when integrated with EVs, energy storage systems, and home energy management systems [9]–[12].

However, many existing simulation tools for microgrids and P2P markets require advanced power system expertise and complex setups. This motivates the development of accessible, fast-prototyping platforms that can support education, early-stage research, and stakeholder engagement. Streamlit—a Python-based interactive dashboard framework—provides an ideal environment to demonstrate P2P market behavior, energy flow, and trading outcomes in a user-friendly manner.

This paper proposes a Streamlit-based P2P trading simulator focusing on a small residential community comprising solar homes, EV homes, hybrid solar–EV prosumers, and normal consumers. The main contributions are:

- A simple but extensible simulation model for P2P trading with DERs and EVs;
- An interactive dashboard for real-time visualization of generation, demand, and trades;
- A modular framework that can be extended with battery storage, blockchain, and AI-based optimization.

II. RELATED WORK

P2P energy trading has been studied extensively in the context of decentralized market mechanisms [13]–[15], game-theoretic resource allocation [16], [17], and DER-based community microgrids [11], [18], [19]. Reviews such as [2], [4], [20] summarize technical, economic, and policy aspects of P2P trading. Blockchain technologies further enhance market transparency, trust, and security [6], [7], [21]. Smart contracts can automate settlement processes and enable secure decentralized transactions [22], [23]. Example implementations

979-8-3315-7191-7/26/$31.00 ©2026 IEEE

include token-based local markets, reputation systems, and privacy-preserving transaction mechanisms [8].

DER integration, including rooftop PV and EVs, has been widely investigated [9], [24], [38]. These studies show how flexible loads and storage can support frequency regulation, peak shaving, and local balancing. Optimal bidding and scheduling strategies for residential P2P participants are discussed in [25], [26]. At the system level, microgrid control architectures, energy management strategies, and local market rules are surveyed in [30]–[32]. In Southeast Asia and Malaysia, policy and regulatory frameworks for DERs, microgrids, and renewable energy are described in [33]–[36], highlighting the relevance of such tools for regional planning and education.

Despite the growing body of literature on peer-to-peer (P2P) energy trading, accessible tools that explicitly visualize P2P market behavior at the household level remain limited. The proposed Streamlit-based dashboard addresses this gap by offering an interactive, self-contained, and extensible simulation platform that enables users to explore prosumer interactions, energy exchanges, and pricing outcomes. Owing to its lightweight web-based design, the tool is particularly well-suited for educational use, exploratory analysis, and early-stage prototyping of decentralized electricity trading mechanisms.

III. System Architecture

Energy trading is triggered when local generation exceeds individual demand. Surplus energy is first allocated to P2P trading among participants before being stored in the community battery. When demand exceeds generation, energy is drawn from the battery or imported from the grid. Each participant is characterized by hourly energy generation and consumption profiles. The proposed system models a small residential community with four types of participants:

- **Solar Home**: A household equipped with rooftop PV acting as a prosumer;
- **EV Home**: A household with an electric vehicle, modeled as a flexible demand;
- **Hybrid Solar–EV Home**: A prosumer possessing both PV and an EV, capable of switching between net seller and net buyer states;
- **Normal Resident**: A conventional consumer without local generation.

Each participant has a time-varying energy profile determined by solar generation and load behavior. When a Solar or Hybrid home has surplus energy, it can sell that surplus to other homes with unmet demand through a P2P market. Fig. 1 illustrates the conceptual model of the P2P residential energy network.

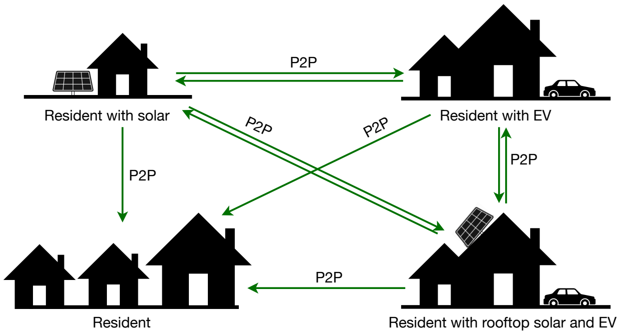


Fig. 1. Structure of P2P electricity model.

The P2P electricity trading model, as illustrated allows households to trade electricity directly with one another, fostering a decentralized and localized energy-sharing system. In this model, participants can generate electricity using renewable energy sources such as solar panels, store the excess energy in batteries, and trade surplus power with neighbors or others within the network. By facilitating direct energy transactions, the P2P model minimizes dependence on centralized power grids, promoting a more resilient and efficient energy ecosystem. It empowers individuals to take control of their energy needs, enabling them to optimize generation, consumption, and storage while reducing waste. This approach not only enhances energy security but also supports the broader integration of renewable energy technologies, contributing to a more sustainable and environmentally friendly energy future.

This diverse set of participants enables the P2P system to function as an efficient, collaborative, and environmentally friendly energy marketplace, supporting the adoption of renewable energy technologies and reducing reliance on traditional centralized power grids. The arrows in the diagram illustrate the flow of electricity and the corresponding financial or credit transactions between participants in the P2P electricity trading system. These arrows represent the dynamic and flexible exchange of energy and payments within the network. For example, a resident with surplus solar energy can sell this excess electricity to a neighbor who needs to charge their electric vehicle (EV). Similarly, a household with stored energy in an EV battery can supply power to a nearby household during peak demand periods, ensuring that energy needs are met efficiently. This flexible and interactive trading system enables direct energy exchanges between peers, reducing reliance on centralized grids and transmission systems. By facilitating localized energy use, it minimizes energy loss that typically occurs during long-distance transmission and optimizes the utilization of local resources, contributing to a more sustainable and efficient energy ecosystem.

IV. Methodology

A. Solar Generation and Load Modeling

Solar generation is modeled using a sinusoidal irradiance profile, which approximates typical clear-sky PV production with a midday peak [2]:

$$G_{\text{solar}}(t) = \max\left(0, \sin\left(\frac{\pi(t-6)}{12}\right)\right) P_{\text{pv}}, \tag{1}$$

where t is the hour of the day (0–23) and P_{pv} is the installed PV capacity.

EV charging demand is modeled with higher activity during evening hours, reflecting common user behavior [10], [12]. Normal residential demand is represented as a stochastic process with bounds derived from typical household consumption [9]. Hybrid homes combine both PV generation and EV demand, leading to alternating buyer–seller behavior throughout the day.

B. *P2P Market Clearing Algorithm*

The P2P matching mechanism implements a simplified supply–demand balancing model inspired by [3], [11], [14]. For each time step:

1) Compute net energy balance for each participant:

$$B_i = G_i - L_i,$$

where G_i and L_i denote generation and load of participant i.

2) Homes with $B_i > 0$ become *sellers* with surplus $S_i = B_i$; homes with $B_i < 0$ become *buyers* with deficit $D_i = -B_i$.

3) Energy is allocated between sellers and buyers according to:

$$E_{\text{trade}}(i, j) = \min(S_i, D_j),$$

where $E_{\text{trade}}(i, j)$ is the energy traded from seller i to buyer j.

4) The P2P price is set as a fraction of the grid price:

$$P_{\text{P2P}} = \alpha P_{\text{grid}},$$

with $0 < \alpha < 1$; in this work, $\alpha = 0.8$, providing an economic incentive for both parties relative to the utility tariff [15], [17].

All trades are recorded with timestamps, seller–buyer identifiers, traded volume, and monetary cost, forming a transaction log suitable for further analysis or later integration with blockchain-based settlement [7], [22].

V. P2P ELECTRICITY TRADING SIMULATION DASHBOARD

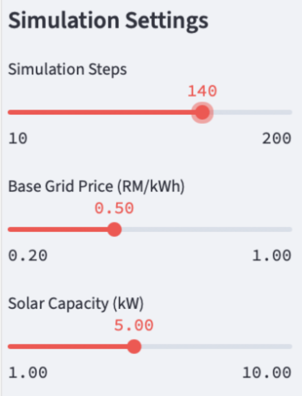
The P2P Electricity Trading Simulation Dashboard is designed as an interactive analytical tool to examine the dynamics of decentralized energy exchange among households equipped with distributed energy resources (DERs), conventional residential consumers, and electric vehicle (EV) owners. The dashboard integrates configurable simulation parameters, real-time visual analytics, and market interaction models to provide a comprehensive representation of a community-scale P2P energy marketplace. This design allows non-experts to explore P2P behavior and understand how DERs and EVs influence community-level energy flows, similar in spirit to other educational or exploratory tools for smart grids [30], [31]. The simulation results illustrate several qualitative behaviors consistent with the literature on P2P energy trading and microgrids [1], [2], [4], [20]:

- **Midday Solar Surplus**: Solar and Hybrid homes often act as net sellers during midday, providing surplus energy to EV and Normal homes at discounted P2P prices.
- **Evening Demand Peaks**: EV Homes and Hybrid homes become major buyers during evening hours, matching empirical studies on EV charging behavior [10], [12].
- **Dynamic Role of Hybrids**: Hybrid Solar–EV homes frequently switch roles between seller and buyer, reflecting the importance of flexible prosumers in local markets [11], [24].
- **Trade Volume Patterns**: The number of P2P transactions peaks when both sufficient surplus and high demand coexist, typically near transitions between day and night.

The dashboard provides an intuitive visualization of these interactions, making it a useful teaching and demonstration tool. While the model abstracts away network constraints, losses, and detailed tariff structures, it captures the essence of market dynamics and prosumer behavior found in more complex studies [14], [18], [32]. From a regional perspective, such tools are particularly relevant for countries like Malaysia and ASEAN members, where DER penetration and regulatory frameworks for distributed energy are evolving [33]–[36]. The simulator can be adapted with local tariff data, solar resource profiles, and policy constraints to support stakeholder engagement and capacity building.

A. *Simulation Settings and Parameterization*

The left panel of the dashboard hosts a configurable simulation environment in which users may adjust key operational parameters. The first parameter, the number of simulation steps, determines the temporal resolution of energy generation, load variations, and market transactions. By adjusting the simulation step size, researchers can study short-duration market oscillations or long-term trading patterns. Fig. 2 illustrates the simulation settings and parameterization of the dashborad.


Simulation Settings

Simulation Steps: 140

Base Grid Price (RM/kWh): 0.50

Solar Capacity (kW): 5.00

Fig. 2. Simulation Settings and Parameterization

The base grid price (RM/kWh) allows the simulation of tariff-driven user behavior and market arbitrage tendencies. Higher grid tariffs typically increase P2P participation, while lower tariffs reduce the incentive for users to engage in local trading. The solar capacity parameter specifies the nominal power rating of rooftop photovoltaic systems, which directly influences the amount of surplus energy available for trading. Collectively, these configurable elements enable the platform to serve as a testbed for scenario-based analysis, regulatory experimentation, and market design evaluation.

B. *Solar Generation Time-Series*

The dashboard visualizes hourly solar generation using a cyclic irradiance-driven generation curve that emulates typical tropical solar behavior. The waveform displays low output during early morning, rapid rise toward noon, and symmetrical decline in the evening. This diurnal pattern reflects realistic photovoltaic generation characteristics commonly observed in equatorial regions such as Malaysia. Fig. 3 illustrates the solar generation in time series.

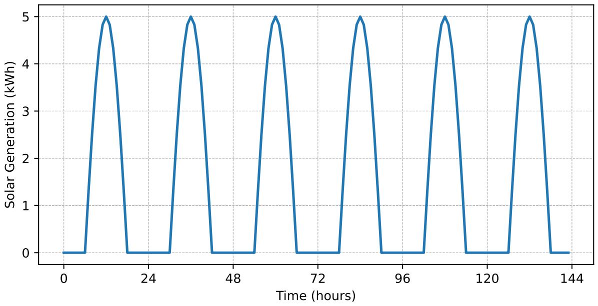


Fig. 3. Solar Generation Time-Series

This time-varying generation is crucial to understanding the intermittent nature of DER supply. During mid-day peak intervals, the system exhibits significant surplus energy, thereby maximizing opportunities for P2P trade facilitation. Conversely, during low-sunlight periods, the community's reliance on stored energy or the central grid becomes more apparent.

C. *Battery State of Charge*

The battery state of charge (SOC) plot demonstrates charging during surplus periods and discharging during peak demand hours, emphasizing the role of storage in energy balancing. Figure 4 illustrates the hourly state of charge (SOC) of the community battery over a 24-hour simulation period in the proposed peer-to-peer (P2P) electricity trading system. During the early hours of the day (00:00–07:00), the battery SOC remains at zero, indicating the absence of surplus renewable generation and the community's reliance on grid imports to satisfy electricity demand. As solar generation becomes available in the morning, the battery begins to charge gradually from 08:00, reflecting excess local generation after P2P energy exchanges among participants. A rapid increase in SOC is observed between 09:00 and 11:00 due to peak solar output and relatively low community load.

The battery reaches its maximum capacity of approximately 20 kWh around midday (12:00) and remains fully charged until late afternoon, demonstrating effective utilization of surplus renewable energy. From 18:00 onwards, the battery enters a discharging phase as community demand increases during evening hours, driven primarily by residential consumption and electric vehicle charging. The SOC decreases steadily and reaches zero by approximately 21:00, after which electricity demand is met through grid imports. Overall, the SOC profile highlights the role of the community battery as a temporal energy buffer, enabling energy shifting from periods of high renewable generation to peak demand hours and enhancing the operational efficiency of the P2P electricity trading framework.

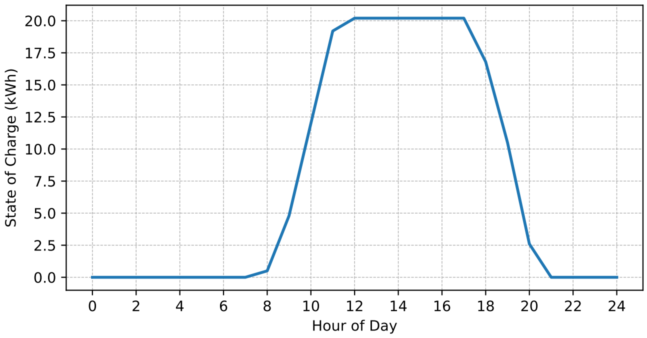


Fig. 4. Hourly state of charge of the community battery showing charging during midday surplus generation and discharging during evening peak demand in the P2P electricity trading system.

D. *EV and Residential Demand Modeling*

Two distinct load profiles are represented: EV charging demand and conventional residential consumption. The EV demand curve demonstrates intermittent high-load blocks that correspond to charging sessions typically initiated during morning departures, midday top-up charging, or evening return-to-home charging cycles. These sessions exhibit significantly higher power requirements compared to normal household appliances. Fig. 5 illustrates the EV and resident demand of the simulation.

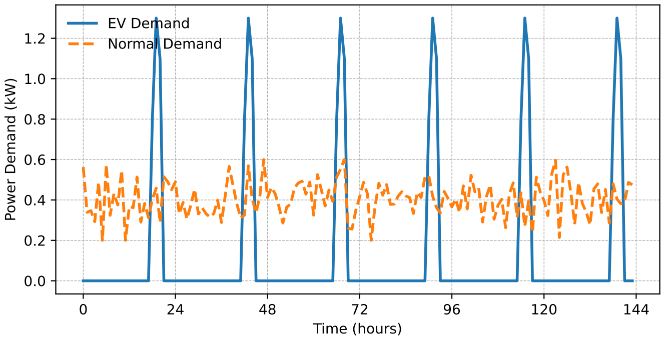


Fig. 5. EV and Residential Demand

The residential demand profile, on the other hand, is modeled as a stochastic low-power signal with short-term fluctuations capturing lighting use, appliance usage, and occupant behavior. The combination of these two demand types produces periods of both synchronized and unsynchronized load events. Understanding this mismatch between load types and solar generation is central to analyzing the feasibility and effectiveness of a P2P trading system.

E. Visualization of P2P Trading Activity

The dashboard computes successful peer-to-peer energy trades per hour based on the availability of surplus solar energy and the presence of local demand from the EV and residential load profiles. This metric is visualized as a time-series bar chart that highlights the intensity and frequency of P2P market interactions. Fig. 6 shows the P2P trading activity of the simulated scenarios.

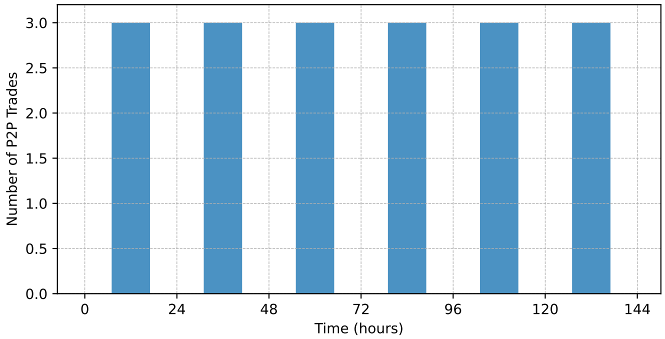


Fig. 6. P2P Trading Activity

Periods of high trading activity typically coincide with the mid-day solar surplus, whereas reduced activity often occurs during nighttime hours when solar generation is absent. The trading activity plot thus acts as a proxy for market liquidity, DER utilization efficiency, and local energy balancing performance. Such visual analytics can inform policymakers and system operators regarding time-of-use pricing design, DER placement strategies, and the need for storage integration.

Table I summarizes the example of daily solar energy generation and electricity demand of individual prosumers within the community microgrid. The data highlight heterogeneous energy profiles across households, where prosumers P1 and P4 exhibit surplus or near-balanced generation relative to demand, while P2, P3, and P5 experience net energy deficits. Such diversity in generation–demand balance creates opportunities for peer-to-peer (P2P) energy trading, allowing surplus energy from solar-rich prosumers to be redistributed to deficit households. This variation forms the basis for evaluating local energy sharing, market clearing mechanisms, and overall microgrid self-sufficiency.

TABLE I.
EXAMPLE OF SOLAR ENERGY GENERATION AND HOUSEHOLD DEMAND OF PROSUMERS

Prosumer	Generation (kWh)	Demand (kWh)
P1	4.17	2.26
P2	2.38	3.52
P3	2.39	4.32
P4	3.43	3.74
P5	1.72	3.68

Table II summarizes the example of representative peer-to-peer (P2P) energy trading transactions executed among prosumers in the community microgrid, detailing the seller–buyer pairs, traded energy quantities, and corresponding transaction prices. The transactions illustrate how surplus solar energy from Prosumer 1 is redistributed to deficit prosumers, namely Prosumers 2 and 3, through bilateral energy exchanges. The variation in traded energy volumes and prices reflects differences in demand levels and localized pricing mechanisms, which may be influenced by real-time energy availability, willingness to pay, or market-clearing rules. These transactions demonstrate the operational feasibility of localized P2P energy trading and provide a basis for evaluating economic benefits, pricing strategies, and overall microgrid efficiency.

TABLE II.
EXAMPLE OF PEER-TO-PEER (P2P) ENERGY TRADING TRANSACTIONS

Transaction	Seller	Buyer	Energy (kWh)	Price (RM)
T1	Prosumer 1	Prosumer 2	1.14	0.51
T2	Prosumer 1	Prosumer 3	0.77	0.35

F. Integrated Insight and System Interpretation

By consolidating generation, demand, and trading information into a unified interface, the dashboard serves as a powerful tool for assessing decentralized energy systems. It enables researchers, planners, and engineers to observe how varying DER capacities, load behaviors, and tariff structures influence the stability and efficiency of a P2P microgrid. The dashboard further supports exploratory analysis for community energy planning, simulation of behavioral responses to price signals, and evaluation of system resilience under different DER penetration levels. Its ability to visually communicate complex interactions makes it suitable not only for technical assessment but also for stakeholder engagement, educational use, and demonstration of microgrid concepts in academic and industrial contexts.

VI. CONCLUSION

This paper presented a Streamlit-based interactive dashboard for simulating peer-to-peer (P2P) electricity trading in a residential microgrid setting. The proposed platform models the behavior of distributed energy resources (DERs), household electricity demand patterns, and local market mechanisms, allowing users to observe energy flows, trading decisions, and price formation through an intuitive web-based interface. By leveraging Streamlit, the system provides a lightweight and accessible tool for rapid prototyping, scenario exploration, and educational demonstrations of decentralized energy trading concepts. Future work will extend the current framework by integrating battery energy storage system (BESS) dynamics, enabling the analysis of energy arbitrage, self-consumption optimization, and grid support services. In addition, the incorporation of blockchain-based transaction ledgers will enhance transparency, traceability, and trust in P2P market operations. Finally, coupling the dashboard with real-world IoT sensor data from smart meters and renewable energy systems will improve the realism of the simulations and pave the way toward near-real-time monitoring and decision-support applications for community-scale microgrids.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support received from the Yayasan Dayak Chair under grant number UNI/F02/DRC/86610/2025. Additionally, we would like to thank the Faculty of Engineering at Universiti Malaysia Sarawak for their support with the Antenna Laboratory facilities.

REFERENCES

[1] Y. Parag and B. K. Sovacool, “Electricity market design for the prosumer era,” *Nature Energy*, vol. 1, no. 4, pp. 1–6, 2016.

[2] J. Kang, R. Yu, X. Huang, S. Maharjan, Y. Zhang, and E. Hossain, “Enabling localized peer-to-peer electricity trading among plug-in hybrid electric vehicles using consortium blockchains,” *IEEE Transactions on Industrial Informatics*, vol. 13, no. 6, pp. 3154–3164, 2017.

[3] J. Kang, R. Yu, X. Huang, S. Maharjan, Y. Zhang, and E. Hossain, “Enabling localized peer-to-peer electricity trading among plug-in hybrid electric vehicles using consortium blockchains,” *IEEE Transactions on Industrial Informatics*, vol. 13, no. 6, pp. 3154–3164, 2017.

[4] C. Zhang, J. Wu, Y. Zhou, M. Cheng, and C. Long, “Peer-to-peer energy trading in a microgrid,” *Applied Energy*, vol. 220, pp. 1–12, 2018.

[5] E. Mengelkamp, J. Gärttner, K. Rock, S. Kessler, L. Orsini, and C. Weinhardt, “Designing microgrid energy markets: A case study: The Brooklyn Microgrid,” *Applied Energy*, vol. 210, pp. 870–880, 2018.

[6] S. Karumba, S. Sethuvenkatraman, V. Dedeoglu, R. Jurdak, and S. S. Kanhere, “Barriers to blockchain-based decentralised energy trading: A systematic review,” *International Journal of Sustainable Energy*, vol. 42, no. 1, pp. 41–71, 2023.

[7] J. Bao, D. He, M. Luo, and K.-K. R. Choo, “A survey of blockchain applications in the energy sector,” *IEEE Systems Journal*, vol. 15, no. 3, pp. 3370–3381, 2020.

[8] M. Pichler *et al.*, “Decentralized energy networks based on blockchain: Background, overview and concept discussion,” in *Proc. Int. Conf. Business Information Systems*, pp. 244–257, 2018.

[9] Z. Tan, P. Yang, and A. Nehorai, “An optimal and distributed demand response strategy with electric vehicles in the smart grid,” *IEEE Transactions on Smart Grid*, vol. 5, no. 2, pp. 861–869, 2014.

[10] Y. Xu, A. A. Peralta, and N. Balta-Ozkan, “Vehicle-to-vehicle energy trading framework: A systematic literature review,” *Sustainability*, vol. 16, no. 12, p. 5020, 2024.

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

[12] N. Hashemipour, P. C. del Granado, and J. Aghaei, “Dynamic allocation of peer-to-peer clusters in virtual local electricity markets: A marketplace for EV flexibility,” *Energy*, vol. 236, p. 121428, 2021.

[13] A. Paudel, K. Chaudhari, C. Long, and H. B. Gooi, “Peer-to-peer energy trading in a prosumer-based community microgrid: A game-theoretic model,” *IEEE Transactions on Industrial Electronics*, vol. 66, no. 8, pp. 6087–6097, 2018.

[14] R. Khalid *et al.*, “A blockchain-based load balancing in decentralized hybrid P2P energy trading market in smart grid,” *IEEE Access*, vol. 8, pp. 47047–47062, 2020.

[15] G. Sun, J. Sun, S. Chen, Z. Wei, and H. Zang, “Market-based coordination of regional electric and natural gas systems: A peer-to-peer energy trading model,” *CSEE Journal of Power and Energy Systems*, 2022.

[16] W. Saad, Z. Han, H. V. Poor, and T. Basar, “Game-theoretic methods for the smart grid: An overview of microgrid systems, demand-side management, and smart grid communications,” *IEEE Signal Processing Magazine*, vol. 29, no. 5, pp. 86–105, 2012.

[17] R. Zhang, M. Lee, D. Zhao, H. Kang, and T. Hong, “Peer-to-peer trading price and strategy optimization considering different electricity market types, tariff systems, and pricing models,” *Energy and Buildings*, vol. 300, p. 113645, 2023.

[18] E. A. Soto, L. B. Bosman, E. Wollega, and W. D. Leon-Salas, “Peer-to-peer energy trading: A review of the literature,” *Applied Energy*, vol. 283, p. 116268, 2021.

[19] M. Karami and R. Madlener, “Business models for peer-to-peer energy trading in Germany based on households’ beliefs and preferences,” *Applied Energy*, vol. 306, p. 118053, 2022.

[20] M. Mishra, A. Singh, R. K. Misra, and D. Singh, “Two-tier peer-to-peer transactive energy market,” *IEEE Transactions on Industry Applications*, 2024.

[21] X. Su *et al.*, “A blockchain-based smart contract model for secured energy trading management in smart microgrids,” *Security and Privacy*, vol. 7, no. 1, p. e341, 2024.

[22] M. Khorasany, A. Paudel, R. Razzaghi, and P. Siano, “A new method for peer matching and negotiation of prosumers in peer-to-peer energy markets,” *IEEE Transactions on Smart Grid*, vol. 12, no. 3, pp. 2472–2483, 2020.

[23] A. Hasankhani, S. M. Hakimi, M. Bisheh-Niasar, M. Shafie-khah, and H. Asadolahi, “Blockchain technology in the future smart grids: A comprehensive review and frameworks,” *International Journal of Electrical Power & Energy Systems*, vol. 129, p. 106811, 2021.

[24] S. Aggarwal and N. Kumar, “PETS: P2P energy trading scheduling scheme for electric vehicles in smart grid systems,” *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, no. 9, pp. 14361–14374, 2021.

[25] D. Kanakadhurga and N. Prabaharan, “Price-based demand response with renewable energy sources and peer-to-peer trading for residential microgrid with electric vehicle uncertainty,” *Computers and Electrical Engineering*, vol. 119, p. 109618, 2024.

[26] R. Faia *et al.*, “Optimal model for local energy community scheduling considering peer to peer electricity transactions,” *IEEE Access*, vol. 9, pp. 12420–12430, 2021.

[27] M. S. Javadi *et al.*, “Optimal self-scheduling of home energy management system in the presence of photovoltaic power generation and batteries,” *Energy*, vol. 210, p. 118568, 2020.

[28] A. Aminlou, M. M. Hayati, and K. Zare, “P2P energy trading in a community of individual consumers with the presence of central shared battery energy storage,” in *Demand-side Peer-to-Peer Energy Trading*, Springer, pp. 143–159, 2023.

[29] A. Boumaiza and K. Maher, “An adaptive home energy management system for prosumers in peer-to-peer trading networks with machine learning optimization,” *Energy Strategy Reviews*, vol. 60, p. 101749, 2025.

[30] L. Ahmethodzic and M. Music, “Comprehensive review of trends in microgrid control,” *Renewable Energy Focus*, vol. 38, pp. 84–96, 2021.

[31] V. Veerasamy *et al.*, “Blockchain-enabled peer-to-peer energy trading and resilient control of microgrids,” *Applied Energy*, vol. 353, p. 122107, 2024.

[32] Y. E. García Vera, R. Dufo-López, and J. L. Bernal-Agustín, “Energy management in microgrids with renewable energy sources: A literature review,” *Applied Sciences*, vol. 9, no. 18, p. 3854, 2019.

[33] M. Z. Jaafar, W. H. Kheng, and N. Kamaruddin, “Greener energy solutions for a sustainable future: Issues and challenges for Malaysia,” *Energy Policy*, vol. 31, no. 11, pp. 1061–1072, 2003.

[34] E. B. Tangka and A. Suwandi, “Enabling sustainable energy communities in ASEAN: A systematic approach to P2P energy transactions on Matakus Island using IoT and blockchain,” in *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 1395, no. 1, p. 012011, 2024.

[35] A. J. Abd Aziz *et al.*, “Review of the policies and development programs for renewable energy in Malaysia: Progress, achievements and challenges,” *Energy Exploration & Exploitation*, vol. 42, no. 4, pp. 1472–1501, 2024.

[36] D. Joshi, “Evaluating the performance of the sustainable energy development authority (SEDA) and renewable energy policy in Malaysia,” *Penang Institute*, 2018.

[37] Y. Li *et al.*, “Digital Twin for Secure Peer-to-Peer Trading in Cyber-Physical Energy Systems,” *IEEE Transactions on Network Science and Engineering*, 2024.

[38] F. R. Albogamy *et al.*, “Real-time scheduling for optimal energy optimization in smart grid integrated with renewable energy sources,” *IEEE Access*, vol. 10, pp. 35498–35520, 2022.

[39] A. Alferidi, M. Alsolami, B. Lami, and S. B. Slama, “AI-powered microgrid networks: Multi-agent deep reinforcement learning for optimized energy trading in interconnected systems,” *Arabian Journal for Science and Engineering*, vol. 50, no. 8, pp. 6157–6179, 2025.