Proceedings of the 11th World Congress on New Technologies (NewTech'25)
Paris, France - August, 2025
Paper No. ICERT 123
DOI: 10.11159/icert25.123

Decentralized Multi-Community Energy Trading: A Blockchain-Enabled Framework

Ameni Boumaiza[1]
[1]Hamad Bin Khalifa University/Qatar Environment and Energy Research Institute
Al Dawhah, Doha, Qatar
aboumaiza@hbku.edu.qa

Extended Abstract

This paper presents a decentralized peer-to-peer (P2P) electricity trading framework integrating blockchain technology to enable secure and efficient energy transactions. The proposed model employs the Alternating Direction Method of Multipliers (ADMM) to optimize energy allocation while ensuring privacy through cryptographic techniques such as Zero-Knowledge Proofs (ZKP) and Homomorphic Encryption. Extensive simulations validate the framework's effectiveness, showing a 15% reduction in transaction costs and an 85% local energy sourcing rate among prosumers, reducing dependence on centralized utilities. The study also introduces Q-GREEN, a functional prototype demonstrating real-time energy trading, transaction monitoring, and market management capabilities. The findings highlight the potential of decentralized energy trading in enhancing grid resilience and sustainability.

Acknowledgments

This work is supported from Qatar National Research Fund through grant AICC05-0508-230001, Solar Trade (ST): An Equitable and Efficient Blockchain-Enabled Renewable Energy Ecosystem – "Opportunities for Fintech to Scale up Green Finance for Clean Energy", and from Qatar Environment and Energy Research Institute are gratefully acknowledged.

References

[1] A. Boumaiza, S. Ben Atitallah, and M. Abid, "Towards Blockchain-Enabled Peer-to-Peer Energy Markets: A Privacy-Preserving Framework for Smart Communities," *Energies*, vol. 16, no. 7, pp. 3051, 2023.

[2] M. Andoni, V. Robu, D. Flynn, S. Abram, D. Geach, D. Jenkins, P. McCallum, and A. Peacock, "Blockchain technology in the energy sector: A systematic review of challenges and opportunities," *Renewable and Sustainable Energy Reviews*, vol. 100, pp. 143–174, 2019.

[3] Q. Wang, W. Guo, and Y. Wang, "A decentralized energy trading framework using blockchain and smart contracts," *Energy Procedia*, vol. 158, pp. 2706–2711, 2019.

[4] 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, Dec. 2017.

[5] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," 2008. [Online]. Available: https://bitcoin.org/bitcoin.pdf

[6] S. Boyd, N. Parikh, E. Chu, B. Peleato, and J. Eckstein, "Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers," *Foundations and Trends® in Machine Learning*, vol. 3, no. 1, pp. 1–122, 2011.

[7] C. Gentry, "Fully Homomorphic Encryption Using Ideal Lattices," *STOC '09: Proceedings of the 41st Annual ACM Symposium on Theory of Computing*, 2009, pp. 169–178.

[8] E. Ben-Sasson, A. Chiesa, C. Garman, M. Green, I. Miers, E. Tromer, and M. Virza, "Zero Knowledge Proofs: An Introduction," *Communications of the ACM*, vol. 64, no. 4, pp. 88–98, Apr. 2021.

[9] A. Boumaiza and F. Mohammed, "Q-GREEN: A Tokenized Energy Marketplace for Qatar Using Blockchain and Federated Learning," Presented at *Vivatech 2024*, Paris, France, 2024.