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THE POTENTIAL FOR PEER-TO-PEER ELECTRICITY TRADING IN GEORGIA

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ABSTRACT

The global energy transition is fundamentally reshaping electricity markets, moving from centralized systems reliant on fossil fuels to decentralized, renewable energy solutions. Distributed energy resources such as solar panels and storage batteries are empowering consumers to become active participants in the energy market. Peer-to-peer (P2P) electricity trading, enabled by blockchain technology, presents a new model for consumers to trade surplus energy directly with one another, bypassing traditional suppliers.
This article explores the potential of P2P electricity trading in Georgia, a country with significant renewable energy resources but limited experience with decentralized energy systems. As Georgia aligns its energy policies with European regulations, the development of a P2P trading market could enhance energy security, empower prosumers, and drive local economic development. Through an analysis of global trends, technological innovations, and the current Georgian energy landscape, this article assesses the opportunities and challenges in implementing P2P trading. By building the necessary infrastructure and fostering public participation, Georgia has the potential to transform its energy market and contribute to a more resilient and sustainable energy future.

KEYWORDS

Peer-to-Peer (P2P) Electricity Trading, Renewable Energy, Blockchain Technology, Decentralized Energy Systems, Energy Market in Georgia

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Introduction.

The energy transition sits at the forefront of the global agenda as countries worldwide work to address urgent existential challenges such as climate change and energy security. This transition is fundamentally reshaping energy markets, which have long been dominated by centralized systems where electricity, typically generated by large-scale producers relying on fossil fuels, is distributed to consumers in fixed, one-directional flows. As nations strive to reduce their carbon footprints and promote renewable energy, they are witnessing significant disruptions in the energy sector, characterized by the integration of renewable energy sources, technological innovation, and decentralized energy production.

At the heart of this transformation is the growing importance of distributed energy resources (DERs), such as solar panels and storage batteries, which allow consumers to generate and store their own electricity. This shift not only challenges the traditional centralized grid model but also opens the door to new and innovative ways of trading energy. Peer-to-peer (Hereinafter: P2P) electricity trading, enabled by technologies like blockchain, represents one such emerging model that empowers consumers to play a more active role in the energy market by directly trading surplus energy with other consumers.

This article explores the potential for P2P electricity trading in Georgia, a country with significant renewable energy potential but somewhat limited experience with decentralized energy systems. As Georgia aspires to align its energy sector with European standards and continue its energy sector reforms, understanding the opportunities and challenges posed by P2P trading could play a key role in shaping its future energy landscape. Through this analysis, the benefits, obstacles, and possible implementation strategies for P2P trading within Georgia's evolving energy market will be assessed.

1. Global trend sin uptake of Renewable Energy.

The global energy landscape has experienced a profound transformation in recent years, driven by the rapid growth of renewable energy sources. As countries strive to meet their climate commitments and reduce reliance on fossil fuels, the adoption of renewable energy technologies—particularly solar and wind power—has accelerated at an unprecedented pace. By 2022, renewable energy sources accounted for 29.1% of global electricity generation, with solar power emerging as the fastest-growing technology [1].

Solar power, in particular, has revolutionized energy markets by becoming the cheapest source of electricity at utility scale [2]. By 2023, it represented three-quarters of all new renewable capacity worldwide [2]. This growth has been facilitated by technological advancements, declining costs, and supportive government policies that promote renewable energy deployment. As the price of solar photovoltaic (Hereinafter: PV) systems continues to decrease, more consumers are adopting these technologies, transitioning from passive electricity users to active producers or "prosumers."

The global shift towards renewables has been further fueled by international frameworks such as the Paris Agreement, which encourages countries to increase their renewable energy targets. In response, many nations have implemented policies that support decentralized energy generation, including feed-in tariffs, net-metering schemes, and subsidies for solar installations. This focus on decentralization, as well as the need for sustainability in policies supporting self-generation, has created a good environment for P2P electricity trading, enabling prosumers to sell surplus energy directly to local consumers, bypassing traditional suppliers.

As more countries embrace renewable technologies, the potential for local, consumer-driven energy markets expands, giving prosumers a more active role in shaping the future of energy.

2. Blockchain Technology and P2P Electricity Trading.

As energy markets continue to evolve, the emergence of blockchain technology has enabled new possibilities for decentralization, particularly through P2P electricity trading. P2P trading refers to a system where individuals or entities can directly buy and sell electricity from one another without relying on traditional intermediaries such as suppliers. This model empowers prosumers to actively participate in energy markets by trading surplus electricity they generate, often from renewable sources such as solar panels and small-scale wind turbines.

The recast Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources provides a foundational understanding of P2P electricity trading. According to Article 2(18) of the directive, P2P trading refers to the sale of renewable energy between market participants through contracts with pre-determined conditions that govern the automated execution and settlement of transactions, either directly between participants or indirectly through a certified third party, such as an aggregator.

Blockchain technology routinely serves as the backbone of P2P trading platforms. By using a distributed ledger, blockchain provides a secure, transparent, and decentralized way to track energy production and consumption. This technology enables the creation of "smart contracts"—self-executing agreements encoded into the blockchain. When the conditions of a contract are met, such as a certain amount of electricity being generated or consumed, the transaction is automatically executed, ensuring efficiency and trust between market participants.

Market participants are equipped with smart meters that record and transmit real-time data on electricity production and consumption. Each participant holds a virtual account, through which they manage their transactions. Once a transaction is added to the blockchain, it cannot be altered, further guaranteeing the integrity of the trading system.

The role of blockchain in facilitating trust and automating energy trading processes is especially significant in decentralized markets, where traditional regulatory oversight may be less centralized. By reducing the need for intermediaries, blockchain lowers transaction costs and removes barriers to entry for smaller participants. This is particularly beneficial for prosumers who can sell their surplus electricity directly to other consumers or to the grid without being bound by the terms of large supply companies.

In addition to cost savings, P2P trading offers the potential to optimize energy distribution on a local scale. Prosumers can sell their excess energy to nearby consumers, reducing transmission losses and contributing to more efficient use of local energy resources. Furthermore, when prosumers are equipped with energy storage solutions, they can store surplus electricity and sell it later when market demand—and prices—are higher.

Hence, blockchain technology and P2P electricity trading reduce costs while enhancing efficiency and resilience in energy systems. As countries explore innovative approaches to modernize their energy sectors, P2P trading, powered by blockchain, could emerge as a key element in the evolution of decentralized energy markets.

3. The Case for Georgia.

Georgia, a country rich in renewable energy potential, stands at a pivotal moment in its energy transition. As it aspires to join the European Union (EU) and aligns its policies with European standards through transposition of the Energy Community acquis, Georgia has made significant advances in reforming its energy sector. The country has been a member of the Energy Community since 2017, which has driven its commitment to comprehensive energy reforms, including the promotion of renewable energy sources and distributed generation.

3.1. Georgia's Energy Landscape.

Georgia's current energy landscape is largely dominated by hydropower, which accounted for 76% of the country's total electricity generation in 2023 [3]. The country's abundant water resources make hydropower a natural choice, but its seasonal nature creates an imbalance in supply. During winter and autumn months, Georgia becomes increasingly reliant on imported electricity or natural gas to power its thermal power plants. This dependency poses challenges to energy security and increases the carbon footprint of Georgia's electricity sector.

While hydropower remains the backbone of the Georgian energy system, the country's renewable energy potential extends far beyond. Georgia has significant untapped solar and wind resources that can diversify its energy mix and reduce dependence on imported energy. Despite this, solar and wind energy accounted for a very small portion of Georgia's energy generation in 2023. The country's sole wind power plant contributed a mere 0.6% of the total electricity generation, while solar energy remains largely untapped, with prosumers accessing it primarily through the net metering scheme [3].

The net-metering scheme is one of the most effective measures, allowing consumers to produce and simultaneously sell electricity. Introduced in 2016, they policy has been a significant step toward empowering active consumers. Under this model, users can sell excess electricity to a supplier, receiving compensation at prices determined by the National Energy and Water Regulatory Commission of Georgia (GNERC). In 2019, the adoption of the Law of Georgia on Energy and Water Supply further increased the maximum capacity of micropower plants from 100 kW to 500 kW, providing greater incentives for small-scale producers. By September 2024, the net-metering scheme had successfully connected 97 MW of capacity to the grid, demonstrating the growing interest in renewable energy self-production among Georgian consumers. The potential for rooftop solar installations is promising. According to recent studies, the rooftop solar potential in four major Georgian cities ranges between 822 and 1,855 MW [4].

While net metering has been a positive step, it is only the beginning of what Georgia can achieve with rooftop solar. Moving forward, expanding the capacity limits for net-metering participants and streamlining the grid connection process could further accelerate the adoption of distributed generation. Additionally, integrating rooftop solar into P2P trading platforms would enable prosumers to sell excess electricity directly to local consumers, bypassing suppliers and maximizing the value of their energy generation. In areas with high concentrations of rooftop solar installations, local trading networks could form, creating self-sufficient energy communities that rely on locally generated, renewable electricity.

3.2. A Foundation for P2P Trading.

Although Georgia does not yet have experience with P2P electricity trading, its policy developments in recent years have laid the groundwork for future implementation. Introducing P2P trading in Georgia could bring significant benefits, from enhancing energy security to empowering prosumers and fostering local economic development. As the country continues to reform its energy sector and capitalize on its renewable energy potential, the next steps involve building the necessary technological infrastructure, refining regulatory frameworks, and encouraging broader adoption of decentralized energy generation.

3.3. Technological Infrastructure for P2P Trading.

One of the foundational elements for a P2P trading market is the development of the appropriate technological infrastructure. Blockchain technology, which allows for secure, transparent, and automated transactions, is central to most P2P electricity trading platforms. By leveraging blockchain, Georgia can create a decentralized ledger where transactions between prosumers and consumers are recorded and executed using smart contracts. These contracts automatically execute transactions based on predefined conditions, such as the amount of electricity traded and the agreed-upon price.

In addition to blockchain, the installation of smart meters is crucial for the success of a P2P trading system. Smart meters enable real-time monitoring of energy production and consumption, allowing participants to track and trade surplus electricity accurately. GNERC and electricity grid operators will need to continue support the widespread deployment of these meters, ensuring that both prosumers and consumers have access to the necessary technology.

Once the technological infrastructure is in place, Georgia could develop a dedicated P2P trading platform that connects prosumers with consumers. Such a platform would provide an online marketplace where energy transactions are conducted, prices are determined, and energy flows are monitored in real time. As part of this process, it will be important to ensure that the platform is user-friendly and accessible to a broad range of participants.

To ensure the efficient functioning of the P2P trading market, Georgia should consider adopting an optimal trading model. A one-hour trading period, similar to the day-ahead market model, could be introduced. This would allow participants to adjust their electricity trades based on real-time market conditions, helping to balance supply and demand more effectively.

Moreover, Georgia could explore offering preferential network service conditions for participants in local P2P trading communities. For instance, communities that generate and trade energy within the same low/medium voltage grid could be exempted from paying high-voltage network fees, as is the case in countries like Portugal. This would incentivize localized trading and reduce the overall burden on the central grid.

While rooftop solar systems are typically small and distributed, large-scale adoption may require upgrades to the distribution grid to handle the influx of decentralized energy sources. Ensuring that grid operators are prepared for a higher penetration of rooftop solar will be critical to maintaining grid stability and avoiding issues like voltage fluctuations.

One of the key challenges in designing policies for decentralized energy systems is the risk of cross-subsidization, where certain groups of consumers - ypically low-income households - bear the cost burden of the energy transition while higher-income prosumers benefit disproportionately. This issue has been observed in other regions, such as California, where the rapid adoption of rooftop solar and net-metering programs led to a significant increase in distribution network costs [5]. These costs were often passed on to consumers who were unable to participate in self-generation due to financial constraints or unsuitable housing conditions.

In Georgia, similar risks exist if decentralized energy policies are not carefully crafted. Prosumers who generate excess electricity and send it back to the grid through participating in the net metering scheme, are currently exempt from network service fees, effectively shifting the costs of maintaining the grid to non-participating consumers. To prevent this, Georgia should consider implementing policies that ensure all consumers contribute fairly to the maintenance of the electricity grid. This could involve introducing capacity-based grid tariffs for all users.

Georgia can also draw valuable lessons from other countries that have successfully implemented decentralized energy policies while mitigating the risks of cross-subsidization and ensuring market fairness. For example, Portugal has introduced a system where P2P trading communities connected to the same low/medium voltage transformer are exempt from paying high-voltage network service fees [6]. By limiting the use of the broader grid for local transactions, Portugal has created an incentive for localized energy trading while maintaining the integrity of the national grid.

3.4. Encouraging Public Participation.

For a P2P electricity trading market to thrive in Georgia, public participation is essential. One of the key drivers of success in decentralized energy markets is consumer awareness and willingness to engage with new technologies. As such, Georgia will need to invest in public education campaigns that inform consumers about the benefits of P2P trading, such as potential cost savings, increased energy autonomy, and the environmental benefits of supporting renewable energy. Additionally, pilot programs or demonstration projects could be launched to showcase the benefits of P2P trading in specific regions or communities. These projects would provide valuable insights into how P2P trading works in practice and help build consumer confidence in the system.

One of the main barriers to fully unlocking Georgia’s rooftop solar capacity is the upfront cost of installing solar PV systems. Although the price of solar panels has decreased significantly in recent years, for many households and businesses, the upfront cost is still too high, making it difficult to invest in renewable energy solutions. Financing mechanisms, such as subsidies, tax incentives, or low-interest loans, could help remove this barrier and make small-scale power plants more accessible.

Conclusions.

Georgia stands at the threshold of a significant transformation in its energy sector, driven by its alignment with European standards and its commitment to modernizing its energy systems. The potential of P2P electricity trading, combined with the country's untapped renewable energy resources, offers a unique opportunity to decentralize energy production and empower consumers. By leveraging technologies such as blockchain and fostering prosumer participation, Georgia can reduce its reliance on imported energy, enhance energy security, and contribute to a more resilient and sustainable energy future.

However, the successful implementation of P2P trading in Georgia will require careful planning and thoughtful policy design. Challenges such as cross-subsidization, grid integration, and ensuring fair access for all consumers must be addressed.

The path forward involves investing in technological infrastructure, such as smart meters and blockchain-based platforms, while also promoting public participation through education and financial incentives. With the right balance of innovation, regulation, and consumer engagement, P2P trading has the potential to play a pivotal role in Georgia's energy transition, helping the country meet its renewable energy targets and strengthen its position within the European energy community.

By embracing this new energy model, Georgia can create a future where consumers are no longer passive recipients of energy but active participants in a dynamic, decentralized market—one that promotes sustainability, economic efficiency, and local empowerment.

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