Evaluating the Transformative Potential of Using Energy as a Community Currency: Perspectives and Propositions for a Rationale Evaluative Framework

Dominic Anto, Sgouris Sgouridis, Atul Mehta & Ashutosh Murti

Abstract

This article examines using energy as a community currency, presenting a global framework that addresses key challenges such as energy accessibility, energy efficiency, cleaner energy transitions, the economy-ecology dichotomy, socio-economic inequality, poverty alleviation, alternative financing mechanisms, and establishing inclusive pathways of wealth generation. The study proposes an evaluative framework for assessing the merits of employing energy as a community currency compared to conventional climate finance mechanisms and community electrification initiatives to advance this concept. The analysis examines the roles of key stakeholders and value propositions through the lenses of community currencies, traditional banking systems, blockchain-based currency, community electrification, and climate finance. The proposed evaluative framework is validated against existing studies, highlighting the potential benefits of using energy as a community currency. It demonstrates its relevance and applicability in assessing this novel approach against established solutions. By offering a systematic solution, this research aims to provide policymakers and development agencies with a robust comparative tool for assessing the feasibility of energy as a community currency within the broader landscape of sustainable development and financial innovation.

Highlights of the study

1. Comparing the existing proposals for using energy as a community currency and proposing a standardized model for addressing the needs of communities seeking energy access, energy efficiency, a greener energy mix, and cheaper access to project financing.
2. Identified the propositions of using energy as a community currency from community electrification, climate financing, and community currency perspectives.
3. Identified the value propositions for different stakeholders and the subsequent gaps in the existing evaluative frameworks
4. Proposed an evaluation framework for using energy tokens as a community currency for community electrification, distributed energy generation, and incentivizing energy efficiency
5. Identified the use of energy tokens as a community currency to be a viable climate financing tool

Keywords: Community currency, climate finance, community electrification, energy tokens, sustainable development

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Introduction

Energy tokens represent an innovative mechanism to incentivize energy efficiency, expand energy access, and support a greener energy mix. Previous studies have explored the adoption of energy tokens as a form of community currency (Anto et al., 2024; Sgouridis, 2011; Woodhall, 2018). Community currencies aim to democratize wealth creation (Johanisova & Wolf, 2012; Woodhall, 2018), foster active citizenship (Kwon et al., 2019), stimulate additional economic activity within communities (Lappeman et al., 2019), mitigate the effects of inflation on the money supply (R. Collins et al., 2013; Wang et al., 2021) and complement fiat currencies by providing an alternative medium of exchange that recognizes contributions to community development (Dash & Sandhu, 2018; Kehoe et al., 1993).

This paper critically examines the concept of using energy as a community currency—hereafter referred to as the energy currency (EC) concept—and the tokens in circulation, termed EC tokens or energy tokens. It also proposes a standardized model for the EC concept to facilitate community electrification, incentivize energy efficiency, increase household incomes, and promote distributed renewable energy generation. An evaluative framework is introduced to systematically compare the effectiveness of the EC concept against conventional community electrification initiatives, existing climate financing mechanisms, and traditional community currency models. Given the emerging nature of this topic, theoretical modeling and simulations provide a foundational framework for understanding the potential implications of energy as a community currency.

Community currencies are alternative money issued by local organizations, businesses, or communities to promote trade within a specific geographic or social group. They aim to stimulate local economic activity, strengthen social ties, and support sustainable development by keeping wealth circulating locally rather than flowing to external corporations or financial institutions (Zeller, 2020). Community currency models are fundamentally grounded in co-creation—the collaborative development of new products or services involving suppliers, customers, stakeholders, experts, and employees (Omezzine & Bodas Freitas, 2022). The co-creation concept assumes significance in the transformative processes associated with distributed community electrification and the foundational resilience of alternative community currencies. The EC concept, from the co-creation perspective in community currency, highlights the integral role of citizen participation, grassroots co-creation strategies, augmenting community (or household) income, and the localization of legal or financial policies in the successful realization of low-carbon transition goals (Johanisova & Wolf, 2012; Khalid et al., 2019). From the co-creation energy perspective, the EC concept incentivizes energy efficiency, helps with cheaper energy access, and reduces the costs of an electrification project (Akpan et al., 2013; Antal et al., 2021). The combined advantages of the EC concept from the community currency and community electrification perspectives are postulated to be:

- ***Re-focus on economies beyond consumption:*** Consumption of goods and services constitutes a fundamental pillar of economic systems, alongside production, distribution, and exchange. Contemporary economies are predominantly shaped by the dominance of fractional reserve banking and the centralized creation of wealth through private bank debt issuance, driven mainly by consumption. Within this context, the energy currency (EC) concept—viewed through the lens of community currency—emerges as a potential paradigm shift, offering a model for decentralized wealth creation focused on the sustainable allocation of resources within consumption-driven economies (Georgeson, 2018; R. Collins et al., 2013; Sgouridis & Csala, 2014). The EC model presents a framework capable of mitigating the cyclical nature of economic collapses and reducing the reliance on costly bailout interventions (Calomiris & Haber, 2016; R. Collins et al., 2013; Turnbull, 2008).

- ***Wealth decentralization:*** The co-creation of energy and the subsequent use of energy tokens as a community currency are central to enabling decentralized wealth creation, in contrast to the prevailing centralized model driven by private banking institutions (as discussed further in Section 2.0). The energy currency (EC) concept offers the potential to support the development of robust decentralized socio-legal institutions, foster peer-to-peer (P2P) community electrification initiatives, and leverage commercially available multi-ledger technologies to facilitate distributed wealth creation (Heldeweg & Séverine Saintier, 2020).

- ***Sustainability***: The decentralized wealth creation process of the EC concept promises to foster responsible consumption practices, engender equitable economic growth, eradicate poverty, and enhance overall quality of life (Truby et al., 2022).

- ***Renewable Energy Integration:*** Facilitate the affordability of distributed energy generation through renewables by implementing the following:
    - Lower cost of financing for community electrification with crowdsourced funds (Ament et al., 2022; Hwang et al., 2017)
    - Optimize the sizing of electrification projects through better peak load management and responsible energy consumption (Georgarakis et al., 2021; Kuznetsova & Anjos, 2021)
    - Incentivizing energy-efficient consumption and distributed energy generation (Sgouridis & Kennedy, 2010)
    - An added stream of income for households from the trading of energy tokens (Hartvigsson et al., 2021; K. Lee et al., 2017)

- ***Local economy support:*** Provide a global platform for trading community currencies that facilitate newer avenues of employment in communities (Kwon, Lee, & Mcintosh, 2019; Michel & Hudon, 2015), address macro-inflation (Sgouridis, 2012), and reward localized production (Collom et al., 2011; Hughes et al., 2013; Seyfang & Longhurst, 2013)

- ***Green finance enabler***: The EC concept could be a practical global climate-finance instrument that does not need obligations akin to renewable energy certificates or priority-sector lending, as seen in international climate negotiations (Conference of the Parties). The success of the EC concept hinges on its financial attractiveness to communities and energy developers, eventually fostering a sustainable way of life. This approach could alleviate the fiscal burdens on governments associated with centralized renewable energy capacity or subsidized public goods delivery (Dinçer et al., 2021; Fu et al., 2021). Consequently, the EC concept may substitute for environmental taxes or financial institutions' mandatory investments in low-carbon transition pursuits (R. Collins et al., 2013).

- ***Inclusive finance***: Mobile banking has shown considerable adaption globally, especially in Global South countries, and is expected to increase a country's GDP by 1.5% (GSMA, 2022).

The EC concept is expected to work on mobile phones, as in the mobile banking system. Like any other community currency, it's expected to be a complementary tool for the solidarity economy.

A quantitative framework designed explicitly for comparative analysis is essential to comprehensively assess the advantages of the energy currency (EC) concept relative to conventional approaches to community development financing, community electrification, and climate financing mechanisms. Although several studies have independently examined EC models and evaluative frameworks for community electrification programs (Banco Mundial, 2020; Heldeweg & Séverine Saintier, 2020; Hubble & Ustun, 2018; Rahmann et al., 2016; Zhang et al., 2019). This study proposes an integrated framework that evaluates community progress across the domains of electrification, climate financing, and community currency innovation.

Recently, the Climate Finance Instrument (CAFI) framework has been utilized to evaluate the impacts of climate finance instruments, based on the International Finance Corporation's (IFC) definitions of climate-related activities and globally accepted principles for tracking climate mitigation finance (Rooprai, 2020). The CAFI framework provides guidelines for qualifying climate financing projects from an environmental perspective; however, it does not assess broader outcomes such as socio-economic development, the creation of income-generating activities, improvements in living standards, or the strengthening of localized institutions. Moreover, financing under the CAFI framework is often subject to the discretion of host country financial regulators, who determine interest rates for debt extended to electrification initiatives.

Accordingly, a structured, multi-dimensional framework is needed to assess the broader impacts of the EC concept on communities as a potential model for advancing a sustainable, low-carbon transition independent of private bank intervention or regulatory mandates. While existing evaluative frameworks address the cost of reliable energy, socio-economic impacts, and carbon footprints, they do not fully capture the primary and higher-order effects of using energy as a community currency.

2.0 Methodology and Flow of Research

To formulate a comprehensive evaluative framework, we thoroughly explore the EC concepts relating to the circulation of community currency (Doria & Fantacci, 2018) and list the holistic development parameters of the community. The principal aims of the paper are as follows:

i) Propose a holistic EC concept based on the existing ideas that have proposed energy tokens as an alternative currency to address the needs of energy access, energy efficiency, affordable clean energy, equitable wealth creation, alleviating poverty, and strengthening localized institutions.
ii) Introduce an evaluative mechanism to facilitate a comparative analysis of the EC concept against alternative climate financing options and conventional community electrification, thereby contributing to a nuanced understanding of the EC concept.
iii) State the null hypothesis and propositions of using energy as a community currency compared to conventional electrification methods.

The study's progression, outlined in Figure 1, follows a structured approach—identifying existing research gaps, examining energy currency concepts across various stakeholder perspectives, and proposing a globally adaptable EC model. Additionally, we designed an evaluative framework for comparing the EC concept with conventional climate financing and community electrification mechanisms.

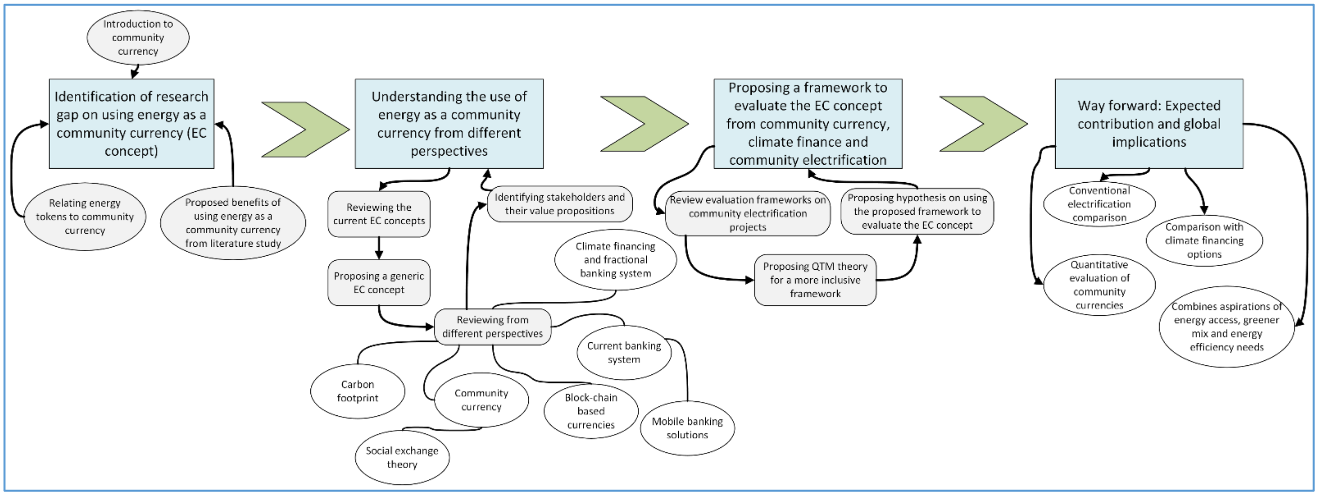

Figure 1: Flow of the study

As explained in Section 1.0, the EC concept addresses community currency, community electrification, and climate financing ideas. This section identifies the gaps and shortcomings of a sustainable low-carbon transition that can be fulfilled by the EC concept from each of these three perspectives. Additionally, stakeholders and their value propositions are explained from the vantage points of community currency, community electrification, and climate financing. Based on the research gap in the existing evaluative frameworks, this study posits a novel conceptual framework designed to assess the impact of the EC concept.

2.1 Review of EC Concepts

There are diverse applications of blockchain in the energy sector (Andoni et al., 2019; Choobineh et al., 2023), studies on the use of energy as a currency (R. Collins et al., 2013), and the 2013 ISTC conference ('In memoriam Nikola Tesla (1856–1943)', 1943). To ground this study in empirical evidence, we analyzed real-world energy token implementations, including:

- SolShare's swarm grids in Bangladesh demonstrated how peer-to-peer energy trading improves energy access and fosters decentralized wealth creation (Groh et al., 2022).
- Simulated studies on Okra's P2P-enabled microgrid networks in Cambodia, validating the feasibility of energy-token-based financing for electrification projects (Anto et al., 2024).
- SunExchange in South Africa, leveraging crowdsourcing to lower electricity costs and enhance accessibility for solar energy adopters (Andoni et al., 2019).
- ATOMcoin's pilot in Masdar demonstrates a scalable energy token application in optimizing peak-load shaving (Marinakis et al., 2020).

Moreover, recent studies have reviewed the workings of various energy tokens as community or alternative currencies, which is the underlying basis of the EC concept. This research extends to the comparative analysis of different EC concepts, evaluating their alignment with the essential requisites of conventional monetary systems (Coetzee, 2016; R. Collins et al., 2013). A synthesis of these comparative evaluations is presented in Table 1 to elucidate distinctions among the various EC concepts concerning their compatibility with everyday monetary requirements.

Table 1: Comparison of EC concepts

Coin name	**NRGcoin** (Mihaylov et al., 2018)	**SolarCoin** (Woodhall, 2018)	**ATOMcoin** (Koasidis et al., 2022)	**Ergo** (Sgouridis & Kennedy, 2010)	**EnergyCoin** (Jian, 2020)
Idea proposed	Coins are issued based on the amount of energy injected or consumed from the P2P grid & load-supply mismatch.	Additional free rewards are independent of other incentives to which solar installation owners might be entitled.	Coins are issued based on the energy saved by the consumers.	Coins are issued upon generation; consumers who save energy can trade in another form or buy/sell at the Ergo exchange.	Blockchain is used to reduce CO_2 emissions by rewarding people.
Value determination of generated tokens	Coins can be traded on open exchange to determine the coin's value. The amount of energy determines one NRG's value and is independent of the grid tariff.	Disburses digital currencies that can be traded on global cryptocurrency exchanges. It uses proof of stake compared to BitCoin, thereby saving energy.	Value is determined by the central budget saved by efficient energy usage.	Ergo, the market determines the exchange value for a monetary benefit.	Intrinsic value purported by carbon offset might even be cycling.
Degree of commercialization	Brussels University arranged the demo, and multiple awards have been won.	Various projects across geographies have been registered.	A case study from Bahrain was conducted.	It was proposed for Masdar City, where 100% of energy is met with renewables.	120M coins have been issued.
Addressing inflation	New coins are issued to the installer every six months for 1 MWh.	Cap the maximum coins at 98bn, based on the IEA RE generation 2010. Restrict to 2% (Turnbull, 2011)	It was not addressed.	Issuance is restricted to the generation forecast and expires upon the forecasted period.	The coins issued per stake are 5.

Limitations of the concept	This concept does not consider distributed Energy Resources like residential or commercial/industrial applications.	Does not have an intrinsic base value.	Energy-saving from the central budget only.	Several active participants determine value.	It depends on carbon tax trading rather than energy.
Expiry details	After six months, the issued coin loses value.	There are no expiry dates.	No details.	Expire based on the priority between peak demand management and energy management.	No details

The EC concepts in Table 1 apply to incentivizing energy efficiency, adding utility-level renewable energy capacity, and augmenting revenue streams for a community electrification project through carbon credits. A comprehensive EC framework must also address the needs of communities striving for energy access, communities seeking a cleaner energy mix, and communities needing energy efficiency. Figure 2 presents a holistic portrayal of the EC concept, taking into consideration the limitations pointed out in Table 1, where prosumers (Espe et al., 2018) are awarded tokens (sometimes addressed as EC tokens in this document) based on the energy supply-demand mismatch at the production time or the energy savings achieved by responsible consumption at any given location. The number of tokens awarded to each kWh produced or responsibly consumed differs based on the energy source, levelized electricity cost at the given site, feed-in tariffs, grid tariffs, and the supply-demand energy mismatch in the given time slot. The parameters mentioned above contribute to the token bonding curve of the EC concept. Token bonding curves are mathematical models defining the relationship between a token's price and supply within a decentralized system. They dynamically adjust the cost based on the total number of tokens in circulation, ensuring a transparent and predictable token economy. These awarded tokens can then be traded in a marketplace or exchanged for equivalent energy consumption before the token expires. The granted tokens are used as a community currency until expiry, facilitating informal community transactions without conventional fiat currency. The number of times an energy token is circulated in the community before the expiry date is the velocity rate (Pokrovskii & Schinckus, 2016) of the energy token for that community.

In Figure 2, each household or prosumer point has intelligent meters. A communication and transaction layer interfaces with these smart meters, facilitated by either the principal grid utility provider, the local grid operator, or a collaborative effort between entities. This layer serves the pivotal function of transmitting and calculating the valuation of tokens, encompassing multiple tokens, while concurrently storing the data encapsulating the energy production and consumption dynamics within the community (Doukas et al., 2019; Strepparava et al., 2022). The additional layer of data infrastructure, communication devices, analytics tools, and allied assets relatable to smart-grids or blockchain-based decentralized electrification projects have shown enough benefits to offset the costs involved in augmenting the required infrastructure (Espe et al., 2018).

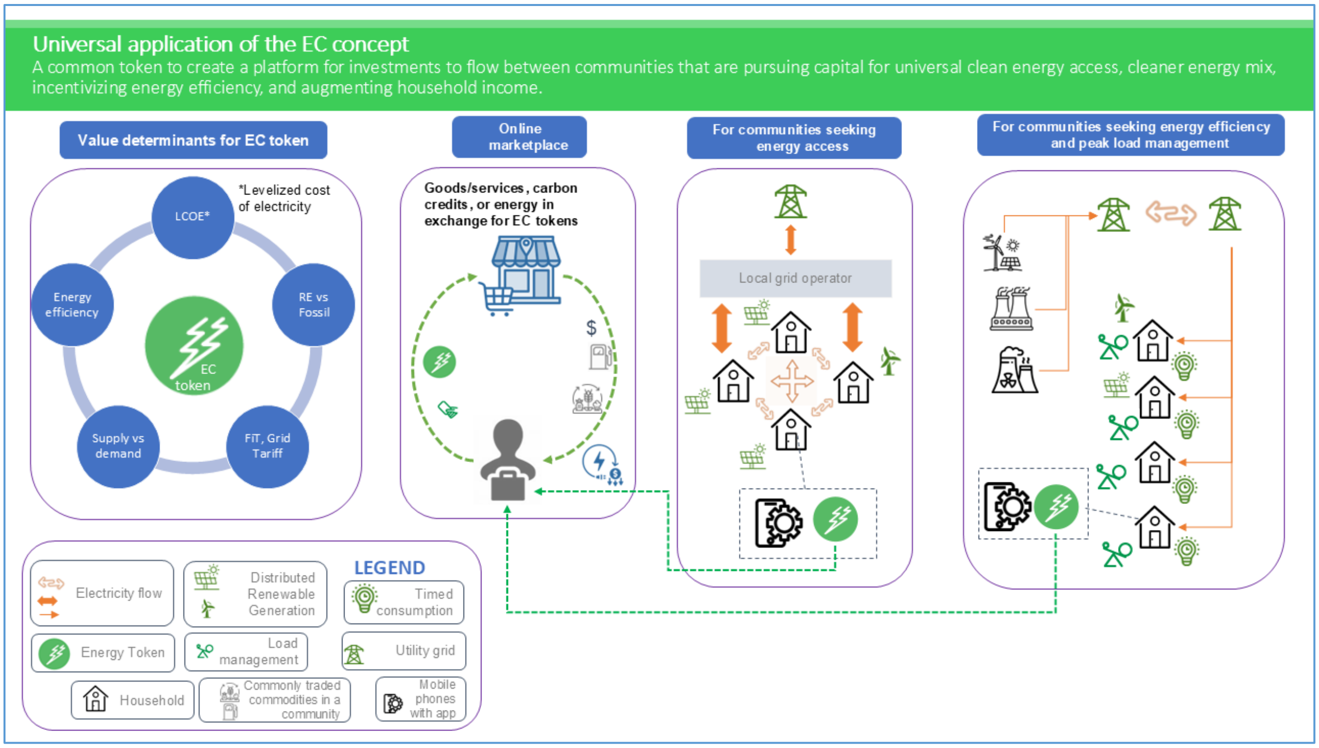

Figure 2: Generic explanation of the universal EC concept

The conventional method of community electrification in Figure 2 can be any of the following, depending on the electrification needs of the community:

- **Energy access:** Solar home systems, decentralized water pumping, or other productive usages of electricity, swarm-grids (Dumitrescu et al., 2022), microgrids and mini-grids can be promoted with the EC concept. Specific examples of Okra (Anto et al., 2024), Solshare (Groh et al., 2022), SolarCoin (Hartsuyker, 2018) and SunExchange (Andoni et al., 2019)
- **Energy efficiency:** Peak-load shaving (Li et al., 2022), savings in dynamically priced energy consumption, and energy-saving (Koasidis et al., 2022) requirements have been observed in Ergo, ATOMcoin, and NRGcoin from Table 1.
- **Distributed renewable energy generation:** Net-metering programs, Feed-in Tariff schemes, Renewable Energy Certificate obligations, captive power-purchase agreements for industries, renewable energy investment mandates, and capital-subsidy programs for households or communities have been juxtaposed with a localized version of the EC concept in NRGcoin, SolarCoin, and EnergyCoin.

The EC tokens earned from a community seeking energy access and those aspiring to energy efficiency or a greener energy mix are traded on the same platform, which means that the EC tokens could become an alternate transnational currency between the developing and developed economies. A standard financing mechanism for the diverse energy aspirations of different communities would mitigate the distributive injustice prevalent in the global climate finance landscape (Islam, 2022). Existing examples from SunExchange from South Africa have already proven that such a crowdsourcing arrangement could provide a cheaper cost of finance to installers of community-electrification projects, a more accessible payment collection mechanism for investors, and a more affordable cost of reliable electricity to consumers (Andoni et al., 2019; Woodhall, 2018). The challenge of standardizing the token bonding curves with local cost factors, supply-demand mismatch of energy interactions in a community, and a transparent tariff policy is backed by a multi-ledger (Blockchain) platform (Marinakis et al., 2018), which will be overseen by regulators from financial institutions and energy distribution agencies.

2.2 Perspective of Climate Financing and the Fractional Banking System

Climate finance refers to the financial resources allocated to address the challenges of climate change. A scant proportion, specifically less than 0.45%, of the overall climate finance emanates from institutional investors (Bauer & Rudebusch, 2020). Climate financing relies predominantly on debt instruments or bonds. Sustainable transition and renewable energy installations receive a meager share of the total bond market globally, as shown in Figure 3, as investments in sustainable transition are believed to be less profitable (Campiglio, 2016). Hence, allocating credit and wealth creation processes potentially undervalues societal investment needs toward sustainable transition (Baer et al., 2021; R. Collins et al., 2013).

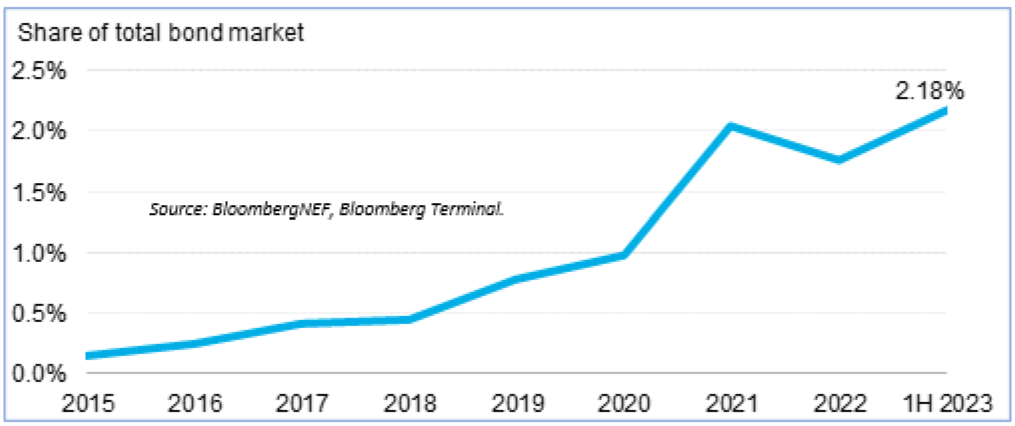

Figure 3: Share of debt issued for sustainable transition in the total bond market (Source: BloombergNEF, Bloomberg Terminal)

From a climate finance perspective, the EC concept could help address some shortfalls by the following:

- Facilitating widespread access to funding for community electrification initiatives globally.
- Serving as a mechanism for delivering energy justice and ensuring an equitable distribution of benefits among stakeholders (Frigo et al., 2021)
- A decentralized model for institutionalizing authority and decision-making processes (R. Collins et al., 2013; Woodhall, 2018) to reduce information gaps and foster strong community networks and collaborative climate initiatives.
- The judicious allocation of debt and credit resources to meet societal and environmental imperatives (Ament et al., 2022), which would enhance local investment.
- Sustainable funding mechanisms can be advocated through crowdsourcing, circumventing the reliance on traditional debt-creation channels (R. Collins et al., 2013; Woodhall, 2018).

- Mitigating the fiscal burden on governmental and regulatory entities associated with decentralized energy generation (Glemarec, 2012; Truby et al., 2022) in aligning incentives for economic activities associated with sustainability goals.

As explained in the earlier sections, the conventional fractional banking system has created a fragile economic system that relies on consumption, a centralized debt-based wealth creation process, allocates less credit for sustainable transition, and develops currencies that derive value from speculation rather than intrinsic value (Calomiris & Haber, n.d.; Galvin, 2020; Larue, 2020; Polzin et al., 2017; R. Collins et al., 2013; Turnbull, 2011). Understanding the EC concept and how it addresses the shortcomings of the conventional fractional banking system is explained in Table 2.

Table 2: Comparing the EC concept with the present banking system

	Conventional banking system	**EC concept**
The logic for introducing money into the market	Methods to control the money supply include setting interest rates, printing money, and setting bank reserve requirements.	Token bonding curves(Summary et al., 2021) are based on energy demand mismatch, electricity generation cost, energy source, and macroeconomic parameters.
Essential asset for wealth creation	Debt or bonds generated by private banks	Energy generated and used productively by communities
Decision maker for the introduction of the new tokens	Central bank	Distributed ledger (Blockchain)
Incentive for climate mitigation	Driven by renewable energy obligations decided by international agreements and national policies	Value of the token, crowdsourcing of electrification projects
Intrinsic value	None	Cost of generating electricity, energy demand mismatch

The EC concept is proposed to be operated on mobile phones just like mobile banking, which, as per simulated studies (GSMA, 2022) is found to increase a country's GDP by about 1.5% by enhancing financial inclusiveness and easing consumer transactions, especially in Global South countries. The effectiveness of community currencies in addressing climate finance asymmetries would depend on their design, implementation, and the specific context of the community. They are not a standalone solution but could be a valuable tool in a broader strategy to achieve climate equity.

2.3 Relationships with Blockchain Currencies

Cryptocurrencies generally exhibit a low correlation with traditional asset classes, which can offer diversification but also reinforce their role as speculative vehicles (Jagtiani et al., 2021). In recent decades, cryptocurrencies have emerged as a transnational currency, streamlining global transactions and decentralizing wealth creation. As of May 2021, the market capitalization of cryptocurrency was $1.1 trillion, with more than 40% of the share being dominated by Bitcoin, followed by Ethereum's 17%. Despite their popularity as investments, cryptocurrencies are not free of problems regarding ecology, the economy, or society. As explained in Table 3, the EC concept tries to resolve some of the difficulties of new alternate currencies using blockchain as part of the execution infrastructure.

Table 3: Comparison of the EC concept with Bitcoin & other BlockChain-based currencies

Issue	The solution offered by the EC concept
Illicit use: More than 40% of Bitcoin transactions are globally meant for illicit purposes like drug trafficking, black market, and anti-social elements (Foley et al., 2019).	The details of every energy token generated are stored in distributed ledgers, which regulators and government bodies can access.
Volatility: The value of the cryptocurrencies presently is more speculative and follows a herd behavior for price determination, thereby lacking an intrinsic value assigned to it (Schinckus et al., 2020).	Transparent algorithms determine the token's intrinsic value, and the token bonding curves determine the minting rate.
Energy use: Environmental concerns over inefficient energy use per transaction exist. Dramatic numbers suggest that the amount of energy consumed by BitCoin mining is more than Venezuela's annual energy consumption (Schinckus et al., 2020).	The algorithm for generating tokens doesn't become complicated with time but is still the same for energy tokens generated over a specific time window.
Scaling: A limited number of transactions and degree of irreversibility with the trades is a major flaw in the large-scale adoption of cryptocurrency (Foley et al., 2019).	Transactions of active tokens are decentralized and platform based. Hence, reversing transactions is possible.

In summary, the EC concept can be learned from the observations and reservations that rendered other blockchain-based alternate currencies primarily vehicles for speculation, as an example to avoid. Regulatory responses vary worldwide—from permissive frameworks in certain jurisdictions (like Switzerland) to outright bans in others (such as China, Vietnam, and Pakistan). This reflects ongoing debates over whether digital currencies should be viewed as currencies, commodities, or securities (Jagtiani et al., 2021). The nascent global regulatory framework for Blockchain-based alternative currencies, including cryptocurrencies, is evolving. Preliminary initiatives, such as the two-pillared system proposed at the G-20 meeting may benefit from a quantitative framework, as presented in this study, to further delineate and refine regulatory measures in this domain. Despite these challenges, blockchain's flexibility, traceability, and decentralized peer-to-peer features can provide the critical infrastructure for real-world EC deployments.

2.4 Review of Community Currencies

Community currencies have been shown to help the economy at times of insufficient liquidity (Zeller, 2020), increase the quality of life, empower active citizenship, create new avenues of informal employment, complement the solidarity economy, and alleviate anxieties amongst excluded populations (Kwon et al., 2019; Seyfang & Longhurst, 2013; Silva et al., 2024). The value propositions of non-monetary compensation being accepted by community members and a preference for a trading platform with a high level of social connection through community currency are expected to extend to the use of energy tokens as a community currency as well (Georgarakis et al., 2021). However, others have also raised concerns about household consumption being restricted by the limited circulation of community currency and the lack of standardization of the community currencies towards a global application (Larue, 2019, 2022). The implementation of the EC concept will have financial implications for the community and policymakers in the following ways:

- **Lower cost of capital:** Crowdsourced capital investments from prosumers would lower the proportion of lending from banks toward electrification projects
- **Additional income stream for communities:** Income from responsible consumption and power purchase agreements with communities would increase the trade surplus of the communities that use the EC concept. Further poverty alleviation, equitable growth, and the inherent ecology-economy dichotomy could be resolved.
- **Additional medium of exchange:** The EC concept would reduce the dependency on the fiat currency as the only means of economic transactions and an alternative mechanism for climate financing.

The impact of community currencies has been qualitatively analyzed (Michel & Hudon, 2015) or based on longitudinal survey studies (Kwon et al., 2019; Lasker et al., 2011) before and after the community currency concept was implemented in a specific locality. Given that alternative currencies based on energy, as listed in Table 1, have not been deployed in practice – at least in sufficient depth of adoption in a community – their impact can only be studied using quantitative simulation. Nevertheless, communities have used complementary currencies, as indicated in Table 4.

Table 4: Community currency projects

Community currency concept	Project details	Location	Impact observed	Reference(s)
Sarafy by Grassroots foundation	The local currency is generated based on community welfare projects	Kenya	Increased informal employment hedges price inflation	(W. O. Ruddick, 2021)
Local Exchange Trading System (LETS)	Participants earn and spend credits within the network, promoting community connections and resource sharing.	Bristol Pound (UK), SoNantes (France), TradeQoin (Netherlands), Chiemgauer (Germany)	Community building by strengthening social ties, engaging underutilized skills, and building trust within the community.	(Larue, 2019; Roio et al., 2015; Seyfang & Longhurst, 2013)
BerkShares	Locally generated currencies in a country are used as a medium of exchange	Berkshire County, USA	There is no discernible impact on business dynamics, and it might not be an economic development strategy.	(Matti & Zhou, 2022)

Some community currencies, such as Kubik (Germany) and renewable energy dollars (Turnbull, 2011) have also been proposed to pay local taxes while mitigating the effects of fluctuations in the global currency. The benefits of community currency stem is an extension of the social exchange theory, stemming from repeated exchange, reciprocity, community support, incentivizing local production, building social capital, and reducing reliance on external economic systems (Chetty et al., 2022; Hoffmann & Glückler, 2023; Jungell-Michelsson & Heikkurinen, 2022).

The current study offers a quantitative framework based on a standardized EC concept and quantity theory of money (Moazzami & Gupta, 1995; Pokrovskii & Schinckus, 2016), which could help policymakers and regulators make informed choices about adopting community currency concepts.

2.5 EC stakeholders and Their Value Propositions

As mentioned in the previous sections, the EC concept is built upon innovative ideas in co-creating energy, decentralizing wealth creation, and augmenting household incomes using energy tokens. Hence, the stakeholders would be from those many concepts. Earlier studies identifying stakeholders in P2P-enabled community electrification projects propose that prosumer communities seek to improve energy efficiency based on economic incentives, leading to environmental transformation (Espe et al., 2018). Key stakeholders from a pure community electrification point-of-view are prosumers, consumers, and energy providers (Mihaylov et al., 2019). Conversely, from the vantage point of community currency, stakeholders encompass users of the community currency within the community, traders engaged in the commerce of community-produced goods with other communities, traders involved in the acquisition or importation of commodities for the community from external sources, local banking institutions facilitating conventional transactions, and regulatory bodies overseeing financial aspects. The views of relevant studies are summarized in Table 5.

Based on the value propositions identified in Table 5, we recognize the gap with the existing frameworks from the literature in Table 6 and propose an evaluation framework in Section 3.0. At the end of arriving at the stakeholders and the value propositions for the stakeholders, a sanity check with a word plot of all keywords used for the literature was plotted in Figure 4. From the findings in Table 5, none of the keywords or perspectives mentioned in Figure 4 are missed out.

Table 5: Stakeholders and value proposition

Stakeholder	Value propositions	Perspectives of the EC concept covered	Potential resistance and (un)addressable concern by the EC concept
Prosumers	• Cost of reliable energy (Espe et al., 2018) • Income from energy generation (Hartvigsson et al., 2021) • Contribution to environmental impact (Georgarakis et al., 2021)	Community electrification	Despite having an intrinsic value, the market value of tokens is determined by speculation, which might be less than the initial value of the token

Consumers	• Cost of reliable energy (Espe et al., 2018) • Additional avenues of income (Sessa et al., 2021)	Community electrification	Disputes from economic transactions using the EC concept might not be easily revokable (Mousavi et al., 2021)
Energy providers	• Asset utilization rate (Groh et al., 2022) • Returns on investment in community electrification project (Espe et al., 2018) • Simplified trading platform (Georgarakis et al., 2021)	Community electrification, climate finance	The primary utility grid has become unstable with a higher mix of renewable energy or a higher proportion of prosumers (Li et al., 2022).
Users of community currency (mixture of prosumers and consumers)	• Household saving from mitigation against inflation (Seyfang & Longhurst, 2013) • Independence from external economic factors (Hoffmann & Glückler, 2023) • Increase in social capital (Ament, 2020; Georgarakis et al., 2021)	Community currency	Though the traded tokens have an intrinsic value, the market price has a certain degree of speculation
Traders interface between the community and other communities	The trade surplus (or deficit) of the community (Seyfang & Longhurst, 2013)	Community currency, conventional currency	Adverse potential of arbitrage between fiat currency and the EC concept
Banks and financial regulators	The trade surplus (or deficit) of the community, cost of capital, and investments for low-carbon transition (Hughes et al., 2013; Lasker et al., 2011; Seyfang & Longhurst, 2013)	Community currency, conventional currency, climate finance	Community currencies are beyond the purview of fiscal and monetary policies set forth by the central banking system
Environmentalists	• Carbon footprint reduction and other principles enshrined in the CAFI framework (Flygare & Flygare, 2019; Khazaei & Schlauderaff, 2019) • Satisfaction of community members for creating a positive environmental impact (Georgarakis et al., 2021)	All perspectives	Additional space and resources would be used for setting up the EC concept compared to the conventional means

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Figure 4: Keywords from the literature

2.6 Frameworks to Evaluate Electrification Projects

Past studies have proposed numerous evaluative frameworks for analyzing the impact of community electrification projects from different perspectives. The summary of the various frameworks and the research gap is identified in Table 6 based on the value propositions discussed later in this study, we are trying to determine the additional parameters that can be used to compare the different climate finance options for community electrification.

Table 6: Summary of evaluation frameworks for community electrification

Framework name or purpose	Fundamental stakeholder in perspective	List of parameters used	Gap(s) in framework based	Unfulfilled value propositions
TESEI model (Ahl et al., n.d.; Khatoon et al., 2019)	TESEI focuses on areas in which microgrids can interconnect with utility grids.	Technical, Economic, social, environmental, and institutional	• Energy access programs • Tie-up of community electrification with climate finance	• Trade surplus • Usage of energy tokens as a community currency
Composite Sustainability Index (CSI) (Rahmann et al., 2016)	Focused on socio-economic & environmental impact on the community	Social, Technical, Environmental, Economic	Weightage of parameters subjective to expert opinion. An algorithm-based, transparent, decentralized solution is needed.	Strength of institutions, community currency perspective
Renewable Energy Friendliness Index (REFI) (Hubble & Ustun, 2018)	Cost-effectiveness of the off-grid microgrid installations	Household Income level, % of energy access, distance from grid, energy costs	The linking of community electrification to decentralized wealth creation and crowdsourced community projects could be covered.	Climate financing, community currency perspectives

RISE (Banco Mundial, 2020)	Energy access and cheaper finance for renewable projects	Electricity access, clean cooking, renewable energy, energy efficiency	Focus on energy access rather than holistic community development	Trade surplus, income augmentation, community currency perspective
Energy Indicators for Sustainable Development (IAEA framework)	Energy meant for development	Household energy use per income group, GHG emissions from energy production, governance parameters	Focus on decentralized energy generation, but alignment with community wealth creation could be added.	Climate financing, community currency perspectives
Microgrid technologies review framework (Hirsch et al., 2018)	Energy and climate financing	Energy security, Economic benefits, clean energy integration	Linkage of community currency and distributed energy generation	Strength of institutions, community currency perspective
CAFI framework (Rooprai, 2020)	Development of finance institutions	Carbon footprint mitigation	Augmenting incomes, cost of energy, and strength of institutions	Trade surplus, income augmentation, community currency perspective

Based on the gaps identified in Table 6, the present research proposes the evaluative framework and pathway for further action in Section 3.0.

3.0 Framework proposal and discussion

Based on the value propositions listed in Table 5, the different aspects of the EC concept, and details on how these aspects could be measured or calculated are discussed in this section. Subsequently, based on the propositions of the EC concept, a framework to evaluate and compare the EC concept vis-à-vis conventional means of electrification and the null hypothesis from this framework is drafted.

3.1 Description of Various Aspects Proposed in the Evaluation Framework

The multiple dimensions of a community's progress identified from the unfulfilled value propositions of Table 6 and the suitable parameters for the proposed evaluative framework are summarized in Table 7.

Table 7: Aspects identified in the proposed framework

Dimension of the community	Parameter#	Proposed parameter	The reason for the parameter from: Community currency (CC) perspective	Community electrification (CE) perspective	Climate finance (CF) perspective
Economic growth	A1	Household & community income	CCs are expected to increase informal streams of income (Refer to Section 2.4)	An increase in household and community income is expected with CE (Refer to Section 2.5)	Payback of projects determines sustainable access to funds for CE.
	A2	Economic inequality (Gini coefficient)	Earlier propositions have indicated CCs promote equitable growth.	CE might lead to greater economic inequality if outcomes from productive energy have limited market access (Acheampong et al., 2022; Hartvigsson et al., 2021)	CF, and especially mitigation finance, is hypothesized to lower economic inequality. (C. C. Lee et al., 2022)
	A3	Trade surplus	CCs have proven to increase economic output in a community)	With CE, the consumption of fossil fuel in Global South countries and utility-grid consumption in developed countries would be reduced—the dependency on commodities imported by the community would be thereby reduced.	The viability of a CE project using CF increases with the economic activities that CE could generate. (Carè & Weber, 2023)
Energy sufficiency	B1	Cost of reliable energy	CC's value hitherto was pegged against trade imbalances. Having an intrinsic value to the CCs derived from CE should be tested in this framework.	CE with a cheaper source of finance and incentivizing energy production or energy-efficient consumption would drive the need for smaller-sized CE projects and lower electricity costs.	The impact of CF was hitherto restricted to low-carbon transition. The present study could establish the effects of CF through CC or CE.

Environmental impact	C1	Carbon footprint	Energy tokens have been observed to have low co-relation with fossil markets (Yousaf et al., 2022)	Reduction of fossil fuel consumption and utility-grid would help reduce carbon footprint.	The primary objective of CF is to enable the transition to a low-carbon economy. (Şimandan & Păun, 2021)
	C2	Strength of institutions	CCs are expected to foster active citizenship and make decentralized decision-making transparent.	P2P-enabled CE projects fix tariffs locally with a transparent pricing mechanism.	The wealth creation process shifts from private banks to CE, thereby transparent processes.

Each of the parameters listed in Table 7 derived from the value-propositions of the stakeholders from Table 5 is expected to address the gaps identified in Table 6, which would drive the null hypothesis of the proposed framework shown in Table 8. The parameters listed in Table 7 are based on the value propositions derived from the stakeholders of different perspectives on the EC concept. The identified parameters represent the various aspects from which a holistic evaluation of a community-upliftment mechanism, like bolstering livelihood, trade surplus, decentralized decision-making, low-carbon transition, co-creation of localized infrastructure, and cheaper finance, is made available to the community. In the subsequent sections and culminating in Table 8, the methods to calculate or measure the parameters derived in Table 7 and the propositions for the EC concept are stated.

3.2 Understanding the Quantity Theory of Money for the EC Concept for Quantifying Anticipated Trade Surplus

As discussed in Table 4, the existing work on assessing the impact of community currencies is based on post and ante data captured from various global communities. When the EC tokens are circulated within a community, there is an exchange of goods/services for the token's value. New tokens are introduced into the community, and existing tokens are removed from circulation upon reaching the expiry date (refer to Figure 1). This mechanism of supplying tokens is equivalent to the conventional fiat currency introduced into a country's money market by the lending mechanism in a fractional banking system (Pokrovskii & Schinckus, 2016; Sullivan, 2012). A simplified view of the quantity theory of money from previous work (Pokrovskii & Schinckus, 2016; Sullivan, 2012) is explained in Equation 1.

$$M \times V = P \times Q \qquad \text{Equation 1}$$

In Equation 1, M represents the money supply, V is the velocity of circulation or the average number of times the money supply has been used to make transactions in each period, P is the average price level, and Q is the output of goods sold in each period. Equation 1 is used to identify the amount of money that needs to be injected into an economy over a given time frame and is equivalent to the logic on which the alternate currency coins are introduced into the market utilizing token bonding curves (W. Ruddick, 2021; Zeller, 2020). The sum-product of 'M' and 'V' for the EC tokens is the value of the community's economic transactions using the EC concept. These economic transactions could be through informal employment, incentives toward active citizenship, socially productive work, or other benefits discussed in Table 4.

3.3 Calculation of Token Introduction and Relation to the Velocity of Money

The algorithm for generating and assigning the intrinsic value of the tokens is based on bonding curves (Mainelli et al., 2019; Ovchinnikov, 2019), and each concept discussed in Table 1 has its token bonding curve. If we assume on a day 'i', α_i tokens are introduced into the system and β_i tokens expire on the same day, then effectively [α_i- β_i] tokens are added to the system, while there are some ε_i tokens that haven't passed or been introduced into the system on the day 'i' but have been carried forward from the previous days. So, the number of active tokens in a system on a day 'i' is ε_i+[α_i- β_i]. From this logic comes below the amount of money on a given day 'i':

$$Mi = \varepsilon i + [\ \alpha i - \beta i] \qquad \text{Equation 2}$$

Based on the above two equations, the velocity V could change daily but remain within a range of values over the long term. Typical velocity of money values for some countries is discussed in Appendix 1. High velocity can indicate economic instability, while low velocity may indicate economic stagnation. The velocity of money indicates how frequently a monetary token is circulated within a given community, and additional means of exchange through the EC tokens or community currency would increase the community's economic activity. Studies on community currencies show that activities that were hitherto unpaid or unrecognized by the community get assigned a financial benefit using community currency. The additional economic activities arising from the community currency fixate the value of 'V' for community currencies (Bendell et al., 2015). Based on historical studies on the velocity of money (Mendizabal, 2006; Onnis & Tirelli, 2015), it's evident that the velocity of money might not always share a significant relationship with inflation but does share a direct relationship with prospects of business opportunities and expansionary measures taken by the government in a macroeconomic landscape. The additional trade surplus owing to the community currency, as listed in Table 7, is calculated by multiplying the M_i from Equation 2 by the local velocity of money from the community.

3.4 Relating Carbon Footprint to the EC Concept

Change in the community's economic activity can create corresponding change in the community's carbon footprint. Like other community currencies, the EC concept is expected to increase informal economic activities, enhance community-building work, and foster active citizenship. Contemporary research suggests that community currencies can help reduce pollution levels of long-distance travel, incentivize communally owned production facilities, and promote a circular economy (Larue et al., 2022).

i) The benefits of using the EC concept for communities seeking energy access involve the change in the amount of fossil fuels or cooking wood/charcoal used and transportation fuel spent in collecting fossil fuels or cooking wood/charcoal. Communities seeking energy access would likely see reduced fuel or wood consumed for cooking and lighting, with community electrification.

   The total carbon footprint reduction by saving fossil fuel, using affordable clean energy, and using efficient energy usage can be calculated using the equation below.

$$C = \sum_{i=1}^{m} c_i \times f_i$$ Equation 3

The amount of fuel saved (f_i in the above equation) could later be approximated for community carbon footprint (C in the above equation) calculation based on the CO_2 emission expected from a unit of the fuel (c_i in the above equation), as put forth in Appendix 2

ii) Communities seeking energy efficiency or a greener renewable energy mix could reap the benefits of cheaper renewable energy, incentives for being energy efficient, and lower costs for reliable energy through the EC concept. Change in size of the community electrification project and the cost of reliable electricity for achieving energy independence of the community: It has been observed through case studies in Bahrain (Marinakis et al., 2020), Korea (Chung, 2020), Canada (Kuznetsova & Anjos, 2021), Tanzania (Hartvigsson et al., 2021) and Kenya (Hanbashi et al., 2023) that promoting energy-efficient consumption using energy tokens, P2P electrification, and peak shaving or peak load management leads to a smaller size of the distributed energy systems to support the same community, which has no incentives.
iii) The degree of reduction in system size and the subsequent reduction in capital costs of setting up community electrification has been simulated using Agent-Based Modelling techniques (Bellekom et al., 2016; Koasidis et al., 2022; Mainelli et al., 2019) and will depend on the load profiles of the households, production patterns of local electrification projects, percentage of prosumers in the community, cost of producing the electricity locally, the time-based electricity tariffs from government utilities, and value of incentives towards households for responsible consumption.
iv) Other potential savings on carbon footprint include changes in the number of milk runs to the ATM (in case of communities that are yet to obtain financial inclusiveness through micro-finance or mobile banking) for a household and the subsequent shift in fuel consumption towards transportation.

Unlike conventional community electrification programs, the additional income stream doesn't give households with better resources an advantage. This understanding implies incorporating a parameter to observe a community's equitable income growth into the proposed framework
.

3.5 Proposed Hypothesis on the Working of the EC Concept

Based on the value propositions listed in Table 5, the aspects identified in Table 7 are proposed to follow the hypothesis as tabulated in Table 8. The statistical validation from Table 8 will allow the comparison of the holistic growth of a community employing the EC concept to the conventional means of electrification or climate financing of the project. The statistical validation can be carried out with tools like paired t-test, Wilcoxon Signed-Rank Test, one-way ANOVA, Krusal-Wallis H test, repeated measures ANOVA, or Friedman Test.

Table 8: Null hypothesis for the EC concept in the proposed framework

#	KPI parameter	Before electrification	After conventional electrification	With simulated EC token implementation	Proposed theory based on current study
A1	Household or community income ($/month)	$A1_a$	$A1_b$	$A1_c$	$A1_a < A1_b < A1_c$
A2	Gini coefficient	$A2_a$	$A2_b$	$A2_c$	$A2_a < A2_b < A2_c$
A3	Trade surplus of the community	$A3_a$	$A3_b$	$A3_c$	$A3_a < A3_b < A3_c$
B1	Cost of reliable energy	$B1_a$	$B1_b$	$B1_c$	$B1_a < B1_b < B1_c$
C1	Carbon footprint	$C1_a$	$C1_b$	$C1_c$	$C1_a < C1_b < C1_c$
C2	Strength of institutions	$C2_a$	$C2_b$	$C2_c$	$C2_a < C2_b < C2_c$

When comparing the framework proposed in this research to related work done on using energy as a community currency, no parameters for comparison were found missing in Table 7. While our study sets a theoretical foundation, we encourage subsequent work to validate these findings through field-based applications and critical case analyses. The evaluation of the EC concept in comparison to the conventional means of community electrification or climate financing would be the prerogative of the project developer, and the outcomes will have to be validated with the stakeholders identified in Table 5. The additional layers of data communication, analytics, and smart meters alongside smart contracts would enable easier data collection and evaluation of the pilot sites or brownfield projects. Some of the underlying assumptions of the proposed null hypothesis in Table 8 are:

- There's no loss of income or livelihood with the implementation of the EC concept. Whilst this is a reasonable assumption, there could be examples like:
    - Loss of livelihood for a lumberjack for a community that relied on firewood, and now moves to renewable distributed community electrification (Anto et al., 2024)
    - Manual energy consumption data collection could be redundant, given that the data collection would be automated and easier with the communication layers added to the EC concept (Strepparava et al., 2022)

- It's assumed in Table 8 that the efficient usage of electricity or the production of electricity would alone impact the income inequality of the community. However, it has been observed in Tanzania (Hartvigsson et al., 2021) that households with existing businesses are more likely to productively use energy for higher income augmentation, which could lead to households with higher income to further increase their incomes and thereby increase the income inequality of the community
- Table 8 assumes that the additional infrastructure costs associated with data communication and analytics in an EC setup offset the cost of capital for adding renewable energy capacity in the conventional means of electrification. Whilst this assumption is reasonable, there might be a minimum critical number of households in a community that need to adopt the EC concept, so that the costs per household of adding new infrastructure are less than the cost of new devices like smart meters or data acquisition tools.

The actual validity of the hypothesis proposed in Table 8 could be validated by setting up pilot sites demonstrating the EC concept. The follow-up action of setting up pilots in each type of community and using the evaluative framework proposed in this research could help understand the critical success factors for the EC concept. The EC concept is expected to help communities with higher self-sufficiency or higher cost of capital in installing distributed community electrification projects and benefit countries that suffer macro-inflation or fluctuations in currency exchange rates. Future studies based on pilot studies could focus on the following:

i) Compare the EC concept with conventional community electrification projects and sustainable finance options
ii) Conducting a sensitivity analysis of the underlying assumptions in the EC concept
iii) Agent-based modeling for identifying the optimal token-bonding curves for using the EC concept
iv) Propose the ideal proportion of prosumers to consumers for a specific community based on localized energy, economy, and environmental parameters.

Further in Table 9, we evaluate the proposed framework and hypothesis upon previous work done on the related work. It's concluded that the parameters mentioned in the proposed framework are sufficient to evaluate the implementation of using energy as a community currency for communities seeking energy access, energy efficiency, localized wealth creation, greener energy mix, decentralized currency systems, and self-reliance, which is representative of the global needs mentioned in Figure 2.

From Table 9, it's clear that the proposed framework and the universal concept of using energy as a community currency in the current research work will offer a global solution to different communities with diverse development needs.

Table 9: Validation of the proposed framework based on earlier research

Cited research work	Parameters from Table 7 that were discussed	Conformance of the expected outcome in Table 8	Validity of the proposed framework
Study on SolShare's swarm-grids in Bangladesh (Dumitrescu et al., 2022; Groh et al., 2022)	• Household or community income (A1) • Cost of reliable energy (B1)	The studies based on Solshare aimed to propose community-based power purchase agreements and consumption patterns in price signals. The study, however, takes the cost of energy for prosumers, consumers & micro-utility providers, which is the base parameter proposed in Table 8.	ü Conforms to an increase in income (A1) and reduction in the cost of electricity(B1) , as proposed by the evaluative framework. **Shows a 2~5% increase in profit or cost savings.**
Grassroots foundation with *Sarafu* community currency used in Kenya(Wang et al., 2021; Zeller, 2020)	• Household or community income (A1) • Trade surplus (A3)	Community currencies are expected to hedge the fluctuations in the national currency(Zeller, 2020)	ü Conforms to the hypothesis proposed in Table 8 for the A1 and A3 parameters. Statistically proves increasing avenues for community income.
Simulated work on community electrification projects with Okra in Cambodia(Anto et al., 2024)	• Household or community income (A1) • Gini coefficient (A2) • Trade surplus (A3) • Cost of reliable energy (B1) • Carbon footprint (C1)	Comply with all parameters except the strength of institutions (C2) from Table 7	ü Conforms to the hypothesis proposed in Table 8 for A1, A3, B1 & C1. A2 is not sufficiently proven. **Confirms to a 5% reduction in cost of reliable electricity and 4% increase in income levels.**
Simulated work on outcomes of using ATOMcoin in Masdar(Marinakis et al., 2020; Sgouridis & Kennedy, 2010)	• Household or community income (A1) • Cost of reliable energy (B1) • Carbon footprint (C1)	C1 is captured through energy savings at the household/community level. The reduction in fiscal burden for the Bahrain government captures B1.	ü Conforms to the proposed evaluative framework's hypothesis in terms of parameters A1, B1, C1. Actual savings **close to 7% of the anticipated savings**
Study on a pilot project of community currency systems to provide a token-based basic income(Avanzo et al., 2023)	• Strength of institutions (C2) • Household or community income (A1) • Trade surplus (A3)	Findings suggest that the project ensured the expansion of the economic network and facilitated trade in the urban communities of Berlin.	ü Conforms with the null hypothesis proposed in Table 8

4.0 The way forward: Expected contribution and global implications

The energy currency (EC) concept represents a transformative framework that disrupts traditional economic models by decentralizing wealth creation within the banking and finance sector, facilitating equitable access to finance while promoting responsible consumption in the energy sector, and addressing environmental imperatives by accelerating the expansion of renewable energy. While previous studies have longitudinally examined the effects of alternative currencies on community economic activity (Dash & Sandhu, 2018; Hughes et al., 2013; Johanisova & Wolf, 2012; Kwon et al., 2019; Seyfang & Longhurst, 2013), they have largely neglected to assess the accompanying reductions in carbon footprints—a critical aspect of any truly sustainable economic transition.

The EC concept simultaneously meets the needs for energy access and energy efficiency. It offers a compelling, scalable solution for policymakers seeking to address climate change while fostering local economic development. If adopted as a global tool that transcends national financial policies, the EC concept could become a cornerstone of energy justice, overcoming barriers to clean energy access and eliminating energy poverty through decentralized energy and wealth creation (Ameli et al., 2021; McCauley & Heffron, 2018; R. Collins et al., 2013). A comprehensive, multi-stakeholder comparative analysis—including perspectives from grid operators, financial regulators, electricity distributors, and energy producers—would offer invaluable guidance to policymakers in crafting pathways for a robust and equitable low-carbon transition.

Furthermore, extending the EC concept beyond the scope of community electrification can forge new linkages across energy systems, connecting tokens generated by utility-scale plants, swarm grids, peer-to-peer (P2P) networks, virtual power plants (VPPs), electric vehicles (EVs), and their corresponding natural energy sources. This integration could pave the way for developing market-based pricing mechanisms for ecological and common goods, catalyzing a shift towards a circular, sustainable economy.

Innovative companies operating at the nexus of decentralized renewable energy, distributed ledger technologies, and climate finance are currently held back by two primary barriers: the lack of rigorous, quantitative validation of alternative currency models (Andoni et al., 2019; Hirsch et al., 2018) and insufficient funding for sustainable energy transitions (Baer et al., 2021; Campiglio, 2016). By providing a robust evaluative framework, this study can equip policymakers with the tools needed to accelerate the adoption of these pioneering solutions. As over 50% of global energy demand is expected to be met by electricity by 2050 (Cozzi & Gould, 2021), the EC concept has the potential to catalyze a faster, more equitable transition to electricity as the dominant form of energy consumption, setting the stage for a low-carbon, decentralized future.

The proposed framework is the first to help evaluate the energy tokens from a community currency and climate financing perspective. The proposed evaluative framework from this work has the following merits:

i) It helps understand the different EC concepts and their relevance to various stakeholders' value propositions.
ii) Provides a common evaluative framework for community currency, community electrification, and climate financing mechanisms, thereby instigating the feasibility of using energy as a community currency.
iii) Help evaluate the societal need for electricity:
   a) An un-electrified or newly electrified community seeking affordable clean energy and an auxiliary source of income from electrification
   b) An under-electrified community seeking cheaper finance for renewable-energy capacity addition
   c) Community aspiring for energy efficiency or a better renewable energy mix
   d) Self-sufficiency in terms of energy consumption

The impact of EC concepts on energy bullying, energy justice, energy mobility, energy access, or sufficientarianism (Monyei et al., 2018) could create innovative solutions for reducing global disparities. Further research from this work could test the framework using field data from communities aspiring to affordable electrification, a better energy mix, energy efficiency, and reliable electrification, or those experimenting with community currency.

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Appendix A

Velocity of money of global economies

Typical values of velocity of money for some global economies are as follows:

Country	Velocity of money	Source
India	1.1	What drives an Economy? – Money (indiatimes.com)
USA	1.427	Velocity of Money: Definition, Formula, US by Year (thebalancemoney.com)

Appendix B

CO_2 content in the fuels used in the community

Material	Basic unit	CO_2 emission upon basic unit consumption	Source
LPG gas	Litre	1533	https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/reference-biomass/facts-figures/carbon-emissions-of-different-fuels/
Charcoal	Kilogram	2420	https://360energy.net/how-does-using-energy-create-carbon-emissions/#:~:text=Multiplying%20660%20by%203.67%20gives,2.42%20kg%20of%20carbon%20dioxide.
Firewood	Kilogram	1163	file:///C:/PhD/Literature%20survey/carbon_footprint_reduction/designs-04-00046-v2.pdf
Kerosene	Litre	2500	https://energypedia.info/wiki/The_Reduction_of_Kerosene_Lamp_Emissions_through_Solar_Lighting#:~:text=Commonly%20accepted%20estimates%20state%3A%20for,are%20released%20into%20the%20atmospher
Diesel	Litre	2614	[1] https://360energy.net/how-does-using-energy-create-carbon-emissions/#:~:text=Multiplying%20660%20by%203.67%20gives,2.42%20kg%20of%20carbon%20dioxide.
Petrol	Litre	2328	[1] https://360energy.net/how-does-using-energy-create-carbon-emissions/#:~:text=Multiplying%20660%20by%203.67%20gives,2.42%20kg%20of%20carbon%20dioxide.