MODEL BRIEF

Blockchain

Low- and moderate-income (LMI) households historically have been underrepresented in the solar photovoltaic (PV) market. Increasing LMI household participation may be facilitated through Flexible Financial Credit Agreements (FFCAs).

An FFCA is an innovative financial or programmatic product that addresses underlying financial barriers for potential LMI solar customers, such as long-term contracting requirements, nontransferable solar subscriptions, credit score hurdles, seasonal income fluctuation, product or vendor skepticism, and limited mechanisms for multiplying or leveraging benefits.

This brief focuses on the use of blockchain to facilitate an efficient, decentralized marketplace of energy producers and consumers to reduce LMI energy costs.

Model Description

Blockchain is a highly secure, decentralized cryptographic technology that verifies transactional data and stores it on all participating computers in an immutable ledger. Blockchain is best known for its first application in the creation of Bitcoin cryptocurrency, but its principles offer a basis for innovation in a variety of industries where the complexity of transactional data is better suited for secure, decentralized management.

Although blockchain-based innovation to date has primarily been situated in the finance sector, the energy market has gained attention as an ideal use-case. Energy markets are traditionally based on a "hub and spoke" model, with the electric utility managing the production and distribution of energy to consumers. Due to the rapid expansion in distributed energy production by consumers and the transformation in electrical demand due to increased electric vehicle (EV) uptake and building electrification, grid management is becoming exceedingly complex and inefficient in a centralized model. This mismatch in sophistication and complexity between the system and its management not only creates increasing levels of inefficiency, but also limits system innovation.

A blockchain-based energy model creates energy-backed digital assets to facilitate a decentralized, transactive marketplace of energy producers and consumers with dynamic and locational pricing. Data is collected from producers and consumers in real time through network devices such as smart meters, and is then fed into the digital platform. The digital platform uses blockchain as an immutable ledger to facilitate peer-to-peer contract management and settlement, using automated processes to establish market-clearing prices for energy trades. Locational transmission costs are incorporated into the system to compensate for physical infrastructure costs while incentivizing distributed energy resource (DER) production in close proximity to consumers.

The resulting price signals incentivize demand response. Participants are able to set preferences for energy sources and price ranges for buying and selling electricity, and the transactions themselves are automated and optimized based on individual preferences and system constraints. For example, a "prosumer" can elect to sell energy from their rooftop solar array and/or battery storage when demand and prices are high, and store excess energy from the system when the load is high and prices are low. Consumers can choose to source electricity from local renewable sources when prices are low, sourcing from carbon-based utility production only when renewable sources are otherwise burdensome. EV owners can even elect to use their vehicles as energy storage systems, selling off stored energy when demand is high and recharging when demand is low to earn a profit.

Under this model, LMI participants will benefit from reduced costs due to increased system efficiency. The blockchain solution should also be designed to enable and streamline the implementation of a variety of FFCA concepts. This model proposes a solution in which LMI participants are certified in the system for set periods of time after proving their qualification

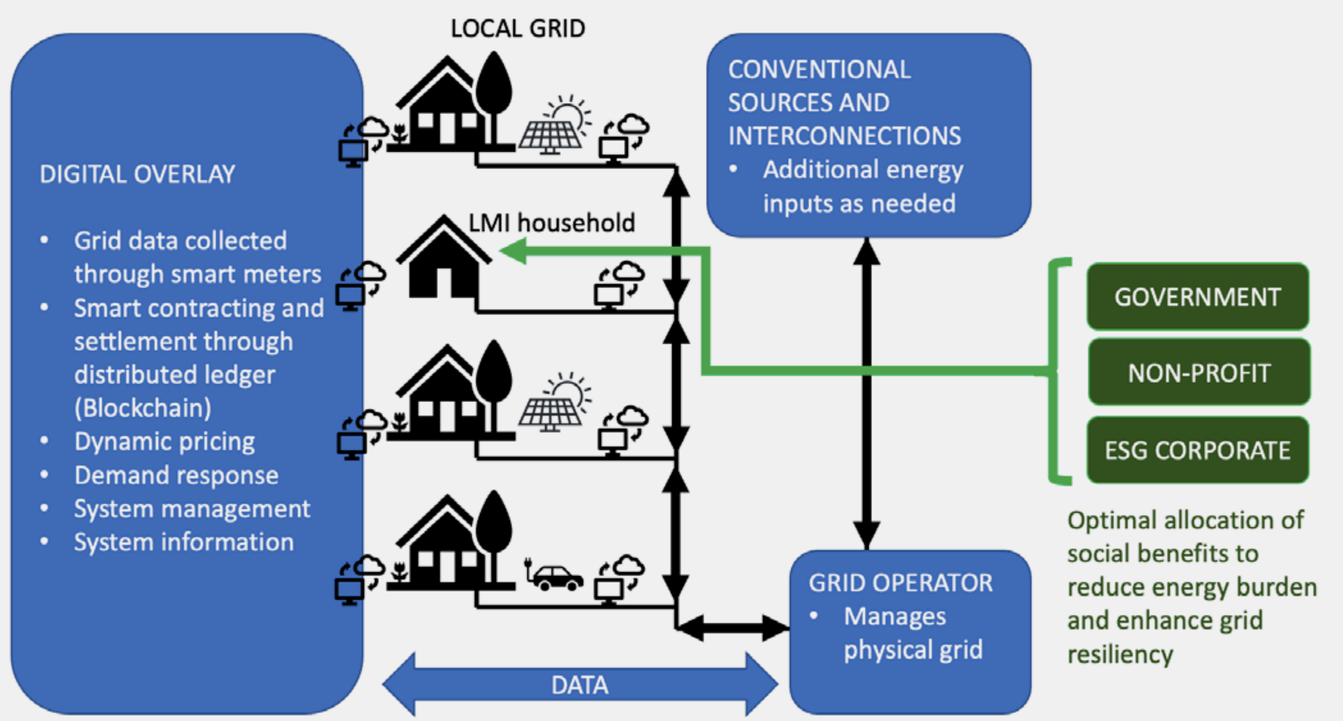

Figure 1: Overview of blockchain-based energy marketplace

for receiving benefits, preventing the need for individuals to provide burdensome documentation any time they apply for benefits or relocate. Once certified, an LMI consumer can be offered a menu of benefits and programs they are eligible for based on their profile. Benefits can be used as bill credits, withdrawn as cash, or even invested into energy assets.

Government, nonprofits, and corporations focused on environmental, social, and corporate governance (ESG) can easily distribute benefits to qualified LMI individuals under this model, and prosumers can elect to donate credits to those in need securely, without accessing personally identifiable information of recipients. In addition, owners of energy assets intended for the benefit of LMI communities can choose to sell discounted energy only to certified LMI accounts.

Crowdsourcing investment for community solar projects is also streamlined, facilitating micro-investments and more meaningful asset ownership for LMI individuals. Utilities can invest in shared DERs and distribute ownership shares within local LMI communities.

The blockchain-based model also generates a rich, real-time, publicly available database of metadata related to LMI market needs, which can inform more effective efforts in promoting energy equity and affordability. With access to locational pricing data, asset ownership rates, and demand and supply data, a nongovernmental organization (NGO) can, for example, identify communities in which a new community solar and storage facility would have the optimal impact for LMI consumers.

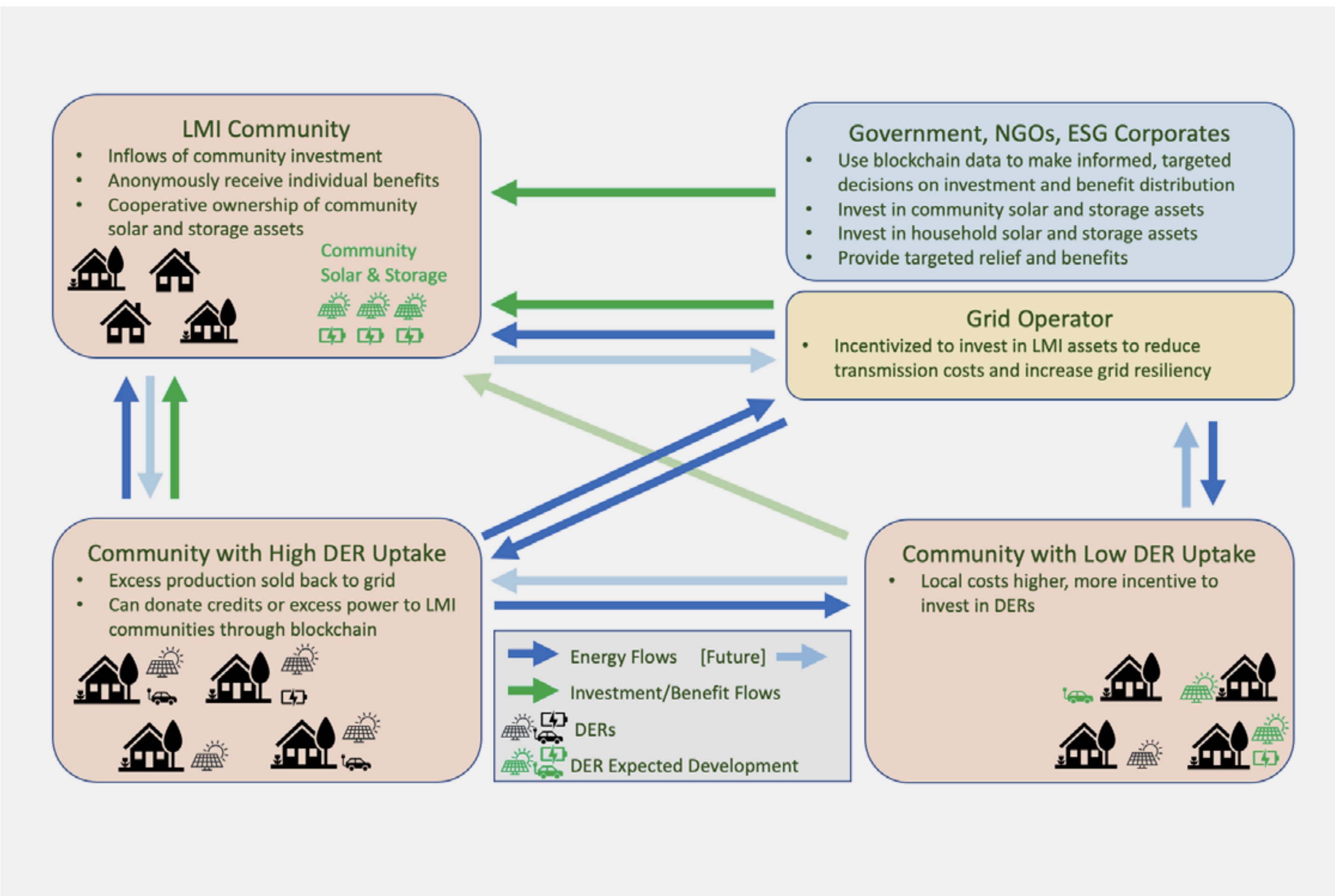

Figure 2: Community-level energy and investment flows over time

Table 1: Potential Benefits and Drawbacks

	Potential Benefits	Potential Drawbacks
Grid Resiliency	• Peak demand is reduced by up to an estimated 20% Federal Energy Regulatory Commission as demand flattens due to effective energy storage utilization, reducing the likelihood of system failure (Moshari & Ebrahimi).	• Although system failure is less likely, failures would be more severe if demand were to exceed generation capacity over the long term (Moshari & Ebrahimi).
Climate	• Efficient management of DER capacity enables more extensive reliance on renewable energy sources and limits the need for dispatchable generation. • Incentivizing DER development increases renewable capacity.	• Certain forms of blockchain technology can be energy intensive.
Utilities	• Increased DER production and storage, combined with variable and locational pricing and decentralized smart grid management, increases efficiency in transmission infrastructure, reducing capital investments. • Utilities benefit from a reduction in administrative expenses. • Utilities owning generating assets benefit from increased capacity utilization (system efficiency). • Utilities subject to earnings adjustment mechanisms benefit from increased system efficiency, increased development of DERs, and greenhouse gas reduction.	• Increased uptake of DERs reduces energy demand.
All Consumers	• Increases in system efficiency reduce costs for ratepayers. In New York, a 1% increase in capacity utilization results in an estimated $221 million–$330 million annual savings. The potential for savings is quite large: New York's capacity utilization rate stands at 55% and is declining (New York State Energy Planning Board). • Consumers have the ability to source local, clean energy. • Consumers have access to the full potential of grid-connected smart devices, allowing for more responsive household demand to minimize energy costs.	• Savings are only realized if they exceed transactional energy costs resulting from the use of a blockchain system. • The ability to access the full benefits of the blockchain system requires the costly implementation of smart metering and smart devices.
Prosumers	• Prosumers have increased control of DER assets due to the ability to engage with energy markets on a more sophisticated level. • Energy storage and dispatch are optimized based on variable market prices. • EVs can be used as energy storage.	• As system efficiency increases, prosumers may see reduced income from DER assets due to lower energy prices.
LMI Consumers	• LMI consumers have easier access to LMI benefits. • The portability and longevity of benefit access are increased without additional burden. • There is flexibility in how benefits are received: bill credits, cash, or investments in DER assets. • There is an increased ability for a variety of stakeholders to provide direct benefits. • Stakeholders have access to better data to make informed decisions about distribution of benefits. • More meaningful shared ownership models are facilitated, allowing for LMI consumers to become prosumers.	• LMI benefits are only enabled if they are built into the system; otherwise, LMI consumers benefit the least from the system due to limited access to smart metering, smart devices, EVs, and DERs.

Implementation of an effective blockchain marketplace would most likely require collaboration between a technology company with a track record in blockchain implementation, the utility, and a financial services company to transact between the energy-backed digital asset and currency.

Similar Examples

A number of pilot projects in the energy space have been planned or implemented. These include the Brooklyn Microgrid, a concept first piloted by LO3 Energy and Con Edison as a peer-to-peer marketplace consisting of a handful of buildings in Gowanus, Brooklyn. Although New York State regulations only allow utilities to sell power, tokenized transactions between neighbors are settled by the utility, satisfying state regulation. Another such project is GridExchange, which is being piloted in the Toronto energy market by Alectra Energy (the second largest municipally owned utility in North America) in partnership with IBM and Interac (a financial services company).

A variety of blockchain-based solutions have also been implemented to improve economic systems for low-income individuals and regions, including secure and streamlined remittances and peer-to-peer micro-credit loans between vendors in Kenya.

FFCA Rubric

The National Renewable Energy Laboratory (NREL) designed an FFCA evaluation rubric composed of four high-level metrics—locational flexibility, financial flexibility and stability, attractiveness, and impact—with fifteen sub-metrics. Stakeholders can evaluate FFCA concepts by rating the sub-metrics, which have maximum scores of 5 or 10, depending on the sub-metric's level of importance. Total scores have a maximum value of 100. These scores are subjective and depend on individual FFCA program design; however, they provide a general framework for judging the merit of a program. Below, the authors rate the Blockchain concept.

Portable

(7.5/10)

Portability is built into system design; may be limited if utilities implement incompatible systems, but regulators should require compatibility

Universal

(5/10)

Depends on state energy market regulations

Applicable

(5/5)

Adoption is fully applicable to all building types

Transferable

(10/10)

Enables streamlined transfer of asset ownership through tokenization

Investable

(5/5)

Enables streamlined investability in shared assets

Accessible

(5/5)

Strong accessibility provides access to a variety of LMI populations

Secure/Transparent

(5/5)

System is based on immutable ledgers and is highly secure

Equitable/Desirable

(7.5/10)

Straightforward program design from the consumer perspective; consumer protections depend on energy and financial regulations

Strengthens Community

(5/5)

Facilitates local shared asset development and the ability to address community-specific energy needs; facilitates management of community microgrids

Leverages Partners

(4/5)

Facilitates innovative benefits and DER development through local community organizations, but does not inherently involve LMI-serving organizations

Mitigates Risk

(5/5)

Does not eliminate financial risk in DER investments, but limits risk through increased direct benefits of DER ownership; investors can more accurately account for the value of and demand for energy

Provides Financial Benefits to LMI

(10/10)

Universal benefits of system implementation weighted toward asset owners, but LMI considerations in this model facilitate LMI asset ownership and streamline distribution of benefits directly to LMI households

Provides Non-Energy Benefits

●●●●● (5/5)

Theoretically enables near total reliance on renewables and localized production and storage; this has the effect of improving air quality due to reduced reliance on fossil fuel combustion, while increasing demand for employment in DER development and investment

Impacts Grid Flexibility/Stability

●●●●● (5/5)

Enables optimized DER production and storage for household and shared DER assets; theoretically reduces peak load and likelihood of failures

Scalable

●●◐●● (2.5/5)

Some states (e.g., New York) have regulatory frameworks conducive to the development of a transactive energy market, but other states will require a regulatory overhaul, so further regulation specific to consumer protection in a peer-to-peer market may be desirable; European Union regulations from 2018 offer a potential model for regulations, both codifying the right to peer-to-peer energy trading as well as offering protections to consumers (IRENA)

Discussion

Although the development and implementation of a blockchain-based energy marketplace is inherently complex from both a technical and regulatory perspective, the inclusion of LMI considerations as laid out in this model would not require any substantial additional complexity. The transformative potential of an energy blockchain is currently driving a high level of interest in and experimentation with energy blockchains by utilities and technology companies worldwide. Incorporating LMI benefits into future pilots and implementation will require effective communication of the benefits of doing so to key stakeholders and the public. Partnerships with utilities and tech companies would be critical for implementation, and partnerships with NGOs and academics engaged in LMI energy concerns would facilitate the development of an effective LMI benefit framework.

Next Steps

Blockchain-based innovations in energy markets have the potential to resolve technological constraints on the optimal management of distributed renewable energy generation and storage. Through decentralized, automated management of a smart grid using distributed ledger technology, demand can be flattened, resulting in substantial improvements in system efficiency, capacity utilization, and resiliency.

These benefits will become increasingly desirable as transactional energy costs (energy demanded by the blockchain platform itself) are reduced through further improvements in blockchain technology. While the technology has the potential to enable LMI benefits consistent with the FFCA framework, these design considerations must be incorporated by energy blockchain innovators long before the technology reaches scale. To that end, FFCA concepts should be introduced to stakeholders through direct engagement and publication of white papers that offer possible frameworks for LMI inclusion. Stakeholders involved in pending energy blockchain pilots should be targeted for more intensive engagement.

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Full Overview of FFCA Products

www.nrel.gov/solar/market-research-analysis/flexible-financial-credit-agreements.html

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