SECURE PEER TO PEER ENERGY SMART GRID USING SMART CONTRACTS ON THE ETHEREUM BLOCKCHAIN

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1. INTRODUCTION

Technologies built on the blockchain is increasingly replacing conventional services where large companies control entire sectors. From fortune.com, "people will no longer have to supply log-in information to the likes of Facebook and Google to interact with others on the web.[1] Instead, they'll keep control of their identity by using blockchain's authentication features". However, energy is still largely tied to centralized grids burning fossil fuels and releasing large amounts of greenhouse gases in the process. A building with solar panels creates large amounts of electricity, but today, it can not be stored efficiently and distributed among peers. Likely, the energy is sold back to the grid of a large energy company who has a monopoly. The inefficient power transfer likely causes power to be lost in the glitches second to second in the grid, caused by the imbalance between load and demand, as well as resistance in the grid. Many companies, most notably Tesla Inc. by Elon Musk, have made Residential and Commercial "Power Walls" where power can be taken from Solar Panels and stored for later use. However, there is a need for a system to handle surplus power and at times, a lack of power in individual systems.

The platform's goal is to create a distributed peer to peer network platform of energy production, storage, energy trading, and transmission of clean, sustainable energy while keeping costs low, which can validate transactions using Proof of Energy technologies for network consensus and uses machine learning to optimize each node. The network is built using smart contracts and tokens on the Ethereum Blockchain[2] , XY Oracle[4] Network, and the Raiden Network to create a trust-less peer to peer distributed platform, and to incentivise good behavior by nodes on the network. The data stream will be powered on the Skycoin network's Skywire VPN, providing a redundant data sharing solution independent of the regular internet.

2. Proof of Energy & Electricity Markets.

Each node is based off several key components: solar panels or a small wind farm, batteries, and a switch, connecting it to other peers. The batteries and solar panels can be switched out and scaled up in the future and still be compatible with the grid. Microgrids form to provide the best pricing and eventually form larger grids by connecting through peers. Transactions are verified through a series of smart contracts and token systems. To do this, a ERC223 / ERC981 Barter upgradable standard token compatible with the Bancor Network called SOLA has been created to isolate the value from the volatility of prices and high transaction fees of the Ethereum blockchain, as well as creating an isolated market with a sole purpose, and can be bought, sold, and traded through public exchanges. Here, C is defined as the consumer, and P is defined as the producer. Essentia Framework will be used to interact with data, create a peer to peer identification system with full data ownership, and ensure that the network functions correctly.

Here, A and B are representative of the energy measured, where A is attempting to send an energy transaction to B. The Core System uses a payment method, on a basis of Proof of Energy. Here, Node B and Node A are pre-arranged, so that A sends 100Wh or some interval to along with the transaction data to C and is recorded into the XY Oracle Network. The Raiden Network[3] is an off-chain scaling solution, enabling near-instant, low-fee and scalable payments. It's complementary to the Ethereum blockchain and works with any ERC20 compatible token. Using

µRaiden on the Raiden Network, nodes can open a payment channel by depositing SOLA. Now, transactions can happen in milliseconds, in real time, and with no transaction fees associated with large blockchains.

When the interval is complete, C sends the payment in the SOLA token, reconciliation is confirmed by both parties which is then recorded into the Ethereum Swarm Database and the XYO ledger by Archivists, and validated using proof of energy. The network will be able to communicate the node's relative and absolute locations using a universal protocol. Every energy node that is connected to the XYO Network will include a device called a Sentinel. Sentinels record and transmit heuristic data relevant to the energy transmission to be chained to nodes above them. They also communicate with other Sentinels and keep a record of these interactions. This history is transmitted to the blockchain via an XYO Bridges, which can either be included on the energy nodes themselves, or as independent devices.

The entire history of heuristic data and device interactions is archived on a decentralized, publicly accessible blockchain. The next interval happens seamlessly, overlapping the previous one, creating a decentralized pay-by-usage system. Node A can then settle the payment channel later to receive the SOLA tokens. The platform allows for rapid transaction settlement, collection of real-time data, user identification, and supply and demand management, and such can load balance transmission of energy across the network.

Participation in the XYO Network is incentivised by XYO Tokens - Sentinels and Bridges are awarded XYO Tokens when the accurate information they provide to the XYO Network is accessed, as well as other devices on the XYO Network that are responsible for archiving and analyzing the data that is provided. This means that all automated nodes are held publicly accountable in the event of an accident, regulation infringement, or breach in safety or personal privacy through the availability of a permanent and unalterable record of all device interactions. This system both limits the amount of fraud and provides the growth of local economies at scale.

Location and energy transaction proof is a large part of the network, however, there are currently no large decentralized solutions for real world to blockchain interaction. The Application is built on top of the XY Oracle Network[4]. Using the XYO Network's Proof Of Origin and Bound Witness to prevent fraud and prove a node's location, transactions are recorded on the XYO Ledger, virtually eliminating the risk of fraud. Each transaction has a digital and physical copy, which can not be altered. Energy nodes will verify their transaction in addition to both party signing the transaction, with crypto-location miners on the network to continuously prove their location.

To provide grid stability and decrease volatility of the supply of electricity, nodes on the network should be incentivised to install battery systems. This can create a source of income for those without solar panels but are in proximity with other users in high demand of electricity. Other unconventional battery types may be added such as those in electric cars while idle and charging. Existing large scale battery systems may be added, such as those used in Microgrids for energy or for electrical grid substations and industrial applications. These may contribute to the grid to fix the large offset in urban areas, in which there may not be as many producers. Electric Vehicle charging stations may also rent out spare power, especially close to large urban areas.

4. **Autonomous Asset Management.** A key component of this platform is a series of applications that can retrieve data from local grids and networks, trade energy autonomously with the network, and then distribute income to different addresses accordingly.

The algorithm will retrieve data from the XYO Network Data Store the relevant data including electricity, storage and usage, supply, and demand by the grid. First, a machine learning platform performs validation and analysis on the data, before building a real time map of the network. The machine learning algorithm can then use local weather data from decentralized platforms to predict the most optimal prices to make the best profit, as well as can also validate and prove energy transactions. The node can then use that to calculate the integrity and details of the node to find the best nodes to trade with. The prices are regulated on the XYO Network with Sentinels, preventing fake transactions and price manipulation. Nodes can only make transactions if

they can validate themselves and other nodes successfully, thus preventing fraud on the network significantly.

The platform provides microgrids and similar providers data and grid management and collection from metering, allowing users to optimize energy grids and usage, and trade energy rapidly with low network fees. The switch can be managed through the switch API, and can be connected to ÐApps[2] through various 3rd party front-ends such as Status Ethereum OS, Metamask, Mist, or the cross platform data management protocol Essentia Framework.

The software used to interact with the grid is on a hardware internet connected switch, which Solar DC to AC systems as well as Battery systems. The Autonomous Asset Management platform uses machine learning to perform analysis on the solar panels and batteries in the system, local system usage, predict future output using weather and historical data, and then subsequently, optimize prices on the node and local system usage.Due to the hyper-competitive prices of the network, the switch will always use the cheapest electricity and attempt to buy at lower costs during the day and store for high peak times optimized with machine learning. The node can autonomously manage energy in it's control, automatically trading and distributing SOLA tokens to addresses. The network thus scales easily, allowing for settlement for wholesale energy marketplaces rapidly with relevant data collection.

This promotes economic growth and community development with access to electricity. In summary, the platform uses machine learning, and thus will be able to support real time metering data, collection of data, user identification and rapid transaction settlement in exchanges with electric vehicle charging stations and thousands of other internet connected devices.

5. **Decentralized Crowdfunding and Investments.** The greatest challenge in the clean energy industry is not the lack of services, but the lack of monetary funds to help those who wish to contribute to the energy market and to their local community. We aim to solve this through a decentralized autonomous organization crowdfunding platform where anybody can help others acquire solar panels. For example, a property owner may want to put a solar system on their property. Through the verified contractor, a smart contract is initiated to raise funding, where a Decentralized Autonomous Organization invests in communities and in return, is given a stake into the equity when electricity is sold later, or used by the homeowner. The sale of energy is thus used to buy back the equity in the solar panels, creating a return for the organization. The Diviners on the XYO Network then validate the interactions between peers and energy transactions. This, coupled with a high return on investment, enables local economies to grow rapidly and provides opportunities for local entrepreneurs, especially those in developing nations and recovering from conflict or natural disasters where conventional power grids would not have the resources.

References:

1:^ Roberts, Jeff John. "Blockchain Offers Hope for the Broken Internet." How Blockchain Offers Hope for the Broken Internet, Fortune, 27 May 2017, fortune.com/2017/05/27/blockchain-offers-hope-for-the-broken-internet/.
2:^ Wood, Gavin. Phd. "Ethereum: A Secure Decentralized Generalized Transaction Ledger." Ethereum: A Secure Decentralized Generalized Transaction Ledger, Gavin Wood, Apr 2014, http://gavwood.com/paper.pdf
3:^ "Raiden Network - Fast, Cheap, Scalable Token Transfers for Ethereum." Raiden Network - Fast, Cheap, Scalable Token Transfers for Ethereum, raiden.network.
https://raiden.network
4: ^ Arie Trouw, Markus Levin, Scott Scheper "The XY Oracle Network: The Proof-of-Origin Based Cryptographic Location Network"
https://docs.xyo.network/XYO-White-Paper.pdf