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A Novel Bitcoin and Block Chain Based Energy Exchange in a New Microgrid Design

Dr. Ghous Bakhsh, Ghulam Rasool
NED University of Engineering & Technology

Corresponding Author e-mail: narejo@neduet.edu.pk

ABSTRACT

We are proposing an approach employing microgrid through which community can efficiently fulfill each other needs of energy. This model will allow micro-grid prosumers to produce, consume and trade energy deprived of any barrier. At present, such a system is not accepted because it requires the "collaboration" of central energy distributors. In our solution, we visualize the use of a blockchain system with the support of smart contracts to provide decentralization. The energy is sent to the central energy storage from the prosumer and is stored there until the consumer claims it. Using smart energy (electricity) meters the flow of electricity can be tracked accurately in both ways, neighbors can purchase spare electricity using tokens rather than paying money. As blockchain takes care of the accounting part, it records the terms of the contracts, tracks how many energy credits have been sold, by whom and to whom. The micro-grid is facilitated by its own smart contract and it can share a desired amount of energy to a connected energy consumer. The customer is aware of how much consumption energy is available at any time in the central storage. The smart contract of the micro-grid takes as input HECs (helios coin) or a bit coin and then releases the energy that corresponds to the calculated amount of HECs or bit coin received by the sender in form of the payment. The test is to monitor these exchanges and repay purchasers and dealers likewise. This project is an effort to utilize blockchain methodology for the trade of sun-based power among members effectively, without any need of third party vendors.

INTRODUCTION

Energy market is becoming increasingly distributed, whether based on Sun, wind, and water or Bio-mass, the intelligent grids are becoming increasingly important. The way power produces and the way it distributes hasn't change for hundred years. So, we are proposing an approach employing microgrid through which community can efficiently fulfill each other needs of energy. For this purpose, peer to peer (P2P) Transactive Energy exchange is a resilient option. The energy trading using blockchain technology, a peer to peer technology, is a decentralized tamperproof ledger of all the energy transactions in a network. Using this technology, partakers in the existing network can approve the transaction eliminate the need of trusted third-party. It allows an authentic procedure for multiple participants to share, and update data. Because of its capacity to both generate and trade abundance power a residential house has been turned into the progressively perplexing vitality "prosumer. Different methodologies occur for actualizing control and business forms in microgrids. A moderately innovative and exceptionally encouraging methodology is utilizing the block chain. The distributed framework based blockchain is truly reasonable for executing procedures of power systems as a multi-agent system (MAS). Block chain is the innovation which empowers clients to trade directly among themselves. Furthermore, what they are exchanging is the energy resulted from microgrids. Blockchain empowers individuals to store and share data in digital format. The put away data can't be duplicated or adjusted once recorded on the blockchain. It maybe thinks about a database equipped for putting away a high volume of data. Though there are many applications of blockchain in the commercial business, lawful and monetary angles, yet little knowledge is available about the processes of P2P energy trading using the blockchain in exchanging stages. As per our approach, the generated electricity can either be consumed within the house, stored in the batteries for future use, or only given back to the grid, thanks to the distributed and universal nature of the blockchain that the produced energy could be traded among the participants in a simpler manner.

BACKGROUND

Beginning in 2013, blockchain [1] has risen as a distributed ledger technology that can broad interactions among the participants deprived of the necessity for a vital clearinghouse. There are numerous research revisions that consider blockchain enabled peer-to-peer (P2P) energy trading as a practical substitute to the traditional energy distribution from a vital electric value. Authors in [2, 3] accomplish the analysis of peer-to-peer energy trading plans, numerous of which route on the basics of the blockchain expertise: PowerLedger, Brooklyn Microgrid, Dajie, Share&Charge, NRGcoin, Solar Coin and the sun exchange. The PowerLedger project [4] proposals a peer-to-peer market places for renewable energy. The whitepaper [5] delivers advanced dialog of the system framework and as well token ecosystem. The Brooklyn microgrid project in the [6], established by New York built startup LO3 Energy objectives in forming the blockchain based peer-to-peer exchange system permitting electricity to be focused to the hospitals, some of shelters and public centers when it is desired. The Dajie project [7] offers a blockchain built stage which permits peer-to-peer power exchange for the separate community, reclamation of the carbon praise for the producer, and expense of the energy and facilities for energy firms. The Share & Charge project [8] suggests an exposed network "EV" charging key established on the newly technology called Ethereum blockchain [9] which permits unified entree to get charged to poles crosswise diverse countries. The other paper named NRGcoin project [10] offers plunders for generating green energy that is (1kWh = 1NRGcoin). Its idea is quite familiar to that of the Solar Coin project [11], where a Solar Coin signifies one MWh of solar based electricity production that is (1MWh = 1SolarCoin). The other Sun Exchange project [12] permits persons to purchase solar cells (panels), and rent them, mostly in Africa continent, and must place once-a-month lease fee collection and supply in the Bitcoin or in the native currency. Another Electron project [13],

introduced in “United Kingdom” and currently working on the technology called Ethereum, that proposes an elastic blockchain based exchanging stage which is supportive to the electricity, gas, as well as community energy plans. In the project Enerchain [14] that provides attention on the peer-to-peer trading in energy marketplace by means of the blockchain technology usage. There are numerous additional blockchain trials that are introduced in the power area, example are LINQ, Block charge and the WePower. [15] blockchain is the facility which permits “solar power generators” to vend photovoltaic production and certifies one who wants to sponsor solar power. The project Blockcharge [16] proposes blockchain driven charging stations for the electric cars across the Germany. The project WePower [17] is a blockchainm based green energy exchanging stand that allows green energy prosumers to increase wealth by allotting tradable aenergyd tokens. All the projects, which have been discussed, are high-level credentials specifying business, lawful and their monetary matters are present. Though facts on the technical application of the blockchain based peer-to-peer trading stands are absent. In [18], authors accomplish an initial economic assessment of mechanism of the blockchain involved in native energy markets. In the research paper [19], authors liken the peer-to-peer energy trading for the business mockups terms and highlight that peer-to-peer energy trading can get popularity in upcoming. In the paper [20], authors reveal the implementation of the blockchain in a campus atmosphere for the transactive energy sales. The Authors in the paper [21] deliberate workings of the microgrid power markets linked to the project named Brooklyn microgrid.in addition to that authors in [22] deliberate commercial models that guarantee the transparency of the energy producer. Numerous other power based applications became possible with the help of blockchain technology, e.g., the usage of the blockchain technology in the “islanded microgrids” to gloss power losses [23] and the supportive release trading requests [24]. And the authors in the paper [25] has also reviewed that how the blockchain based technology works in the Internet of Thing (IoT) settings.

BLOCKCHAIN IN THE ENERGY SECTORS

Blockchain is quickly rising as a potential distinct advantage of how worth is made in all parts and even how community works on the loose.It is basically an appropriated record intended to record data straightforwardly and in a decentralized way [26, 27].Every transaction is put away as an endless supply everything being equal as a widespread agreement among the participants, and from that point connected to past squares shaping a chain which is shared inside the system for straightforwardness and responsibility [28, 29]. This innovation got over 1.4 billion USD in business speculation during 2014 to 2017, with organizations likewise progressively running preliminaries for open administrations [30]. With the collaboration of commonwealth bank of Australia and World Bank Innovation Labthe first blockchain-based bond was released in Australian dollars in 2018 [31]. What's more, various national banks, for example, in Sweden, Denmark, and the United Kingdom are investigating conceivable outcomes of making national digital currencies [32].

BLOCKCHAIN’S FUTURE WITH SMART GRID AND ENERGY MARKETS

A few authors examine that future energy frameworks will be appropriated, upheld by digital sensors and ICT for bi-directional correspondence among all parties on smart grids [33, 34, 35]. The smart grids can operate continuously in real time, booking loads dependent on framework requests, production, costs, and agreements [34].

Microgrids and smart grids are relied upon to keep on turning into another energy worldview [34, 36], with microgrids considering higher portions of neighborhood sustainable power source, prosumers exchanging energy inside networks within the community, and expanded flexibility [37, 36].

Microgrids are an assortment of neighborhood, distributed generation and loads in a reasonable framework associated with the utility network grid [38, 39], with the capacity to work on-grid just as off-grid in islanding mode [40]. These frameworks are not yet utilized in a few areas, yet projections demonstrate a potential yearly market estimation of 200 billion USD [40]. Microgrids empower neighborhood (local) energy markets, which are topographically restricted with one of a kind valuing components between interconnected entertainers [37]. Renewable sources can be adjusted by means of capacity and ICT [41], with abundance energy consequently put away or sold dependent on pre-decided plans of action [42]. On the off chance that blockchain innovation is presented, P2P exchanging may likewise be led inside microgrids, notwithstanding power trade by means of physical and virtual utility framework association [43, 44].

BLOCKCHAIN

Blockchain is a dispersed database called record fit as a fiddle of affixed information records called blocks and is comprised of a data and a connecting part. The data part can hold different original sorts of data, for example, financial records or exchange subtleties yet additionally computationally general information control rules, that can be translated, mutual and got to by everybody approved. The connecting portion has “connection to the past block” in the chain, regularly a figured hash an incentive over the past block. As a result of affixing with hash capacities cryptographic mark for connecting the blocks, it very well may be guaranteed that marked blocks can't be altered without being perceived.

A significant angle in utilizing the blockchain innovation is smart contracts and decentralized applications. The Smart contracts are a strategy to frame understandings through the blockchain. The type of blockchain known as “Ethereum” is a decentralized stage which operates smart contracts, and has worked in Turing absolute programming language that can be used to form the brilliant agreements and distributed requests.

Consensus Mechanisms

In conventional installments, outsiders, customarily banks, are trusted for keeping up exchanges and record adjusts. Interestingly, the blockchain is a trustless and appropriated accord framework. Outsiders are not required for exchanges. Everybody can check the composed data, since everybody has a duplicate of the blockchain. It is significant, that everybody has a similar duplicate. To arrive at this framework wide steady agreement, an accord instrument, (POW) Proof of work or (POS) Proof of stake is required.

1. **Proof of Work**

In this framework, excavators contend to settle a "computational riddle", that is respectably difficult to comprehend yet the outcome ought to be anything but difficult to check. The riddle includes assurance of a nonce which means if block’s information is hashed, that hash must be littler than a darned limit. Typically beast power is utilized for unraveling the riddle. This procedure is known as mining. As figuring intensity of the system builds, blocks are made quicker. Responding this alteration, the darned edge, known as difficulty, and is intermittently adjusted to manage the block age rate. First excavator to search an answer promotes it to the system and is remunerated. Mining fills two needs one is authenticity checking of exchanges and second is making new coins by compensating diggers.

2. **Proof-of-Stake (PoS)**

In this framework excavators don't contend, rather a validated set is kept up. Anybody, who claims blockchain coins, can be the part of this place by sealing his every coin, known as stake. Validator takes an interest in building the blocks process, in which two significant kinds of agreement calculations are utilized. In blockchain based Proof of Stake the validator, has the option of making the block, is occasionally pseudo-arbitrarily chosen. In Byzantine-faulttolerant-style Proof of Stake the validators are able to suggest blocks, doing so the privilege is haphazardly doled out, moreover validators concur or differ on the suggested blocks by casting a ballot. The makers of blocks will have exchanges charges rather than block rewards. Hence, all coins are made before all else, and their number never shows signs of change. Preferences Proof of Stake that less amount of power is required for accord.

3. **(POA) Proof of Authority**

In this type of framework just approved nodes only reserve the privilege to make new blocks. The framework doesn't depend on settling "computational riddles" and is generally utilized for consortium blockchains.

Blockchain Types

In view of access consents and change capacities, three different types of blockchains are described below:

1) Public Blockchain

This type of blockchains are open and completely “decentralized". Anybody can peruse the blockchain, send exchanges and partake in the agreement procedure. To verify an open blockchain, some of the “consensus mechanisms” will beneeded. Because of transparency, belief and these blockchains are highly used.

2) Consortium Blockchain

This type of blockchain is constrained by particular gatherings, in which only described set of nodes takes an interest in the agreement procedure. They are viewed as" somewhat decentralized". The correct consent might be open or limited. Points of interest are that they are quicker and give more protection. This kind of blockchain is for the most part utilized in the economic area.

3) Private Blockchain

This type of blockchain is typically claimed by single individual or by an organization, and has compose consent to verify the exchanges. The favorable circumstances of the private blockchain are that the blockchain is alterable (for example exchanges can be returned), the validators are recognizable, less expensive exchanges, quicker accord calculations conceivable and more noteworthy degree of protection

if the read consents are limited. For the most part they are utilized for organization inner procedures like database the executives and evaluating.

PROPOSED P2P ENERGY TRADING VIA BLOCKCHAIN PLATFORM

The proposed model of peer-to-peer energy trading via blockchain technology platform is designed to allow the excess energy of photovoltaic cells for trading purpose in the local neighborhood. Fig 1 shows the high-level architecture of this trading system along with its main components.

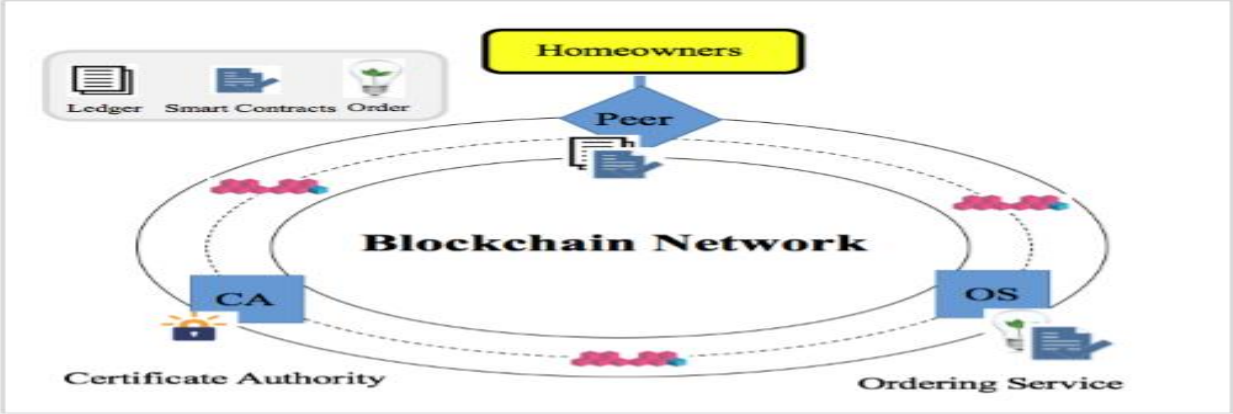


Fig 1. High-level Architecture of Blockchain Network

- **Peer** is claimed and kept up by each gathering of members. 'Peer' is a system substance that submits exchanges and keeps up a record, on which a smart contract races to encode resources and exchange guidelines.
- **Ordering Service (OS)** is a hub that gives a common correspondence channels to the connected members, offering a communicate administration for messages containing exchanges and actualizing administration conveyance ensures.
- **Certificate Authority (CA)** gives enlistment of personalities and issue enlistment certificates for members

A. Participants

Participants are those that are involved in the transaction of the excess energy in a neighborhood. Homeowners are of two types one is “prosumer” who has the solar PV at his rooftop whose house can consume, produce and trade electricity, and second is “consumer” who can only consume electricity.

Every house hold is enrolled utilizing the accompanying parameters: Name, balance and email. The balance determines the owner's available digital balance in his wallet, which is utilized to purchase/sell energy. Every node is distinguished by a one of a kind ID, which is an email address. At the point when an exchange happens, the digital currency is updated in the corresponding wallet.

B. Assets

The 'kWhlisting' is an asset that is consequently created by the framework consistently, indicating listingid, state, PVoffer and BUYoffer. The listingid indicates date and time of electricity trade. There are mainly two alternatives for state ACCEPT_OFFERS, showing that ideas from merchants/purchasers are presently acknowledged, and AUCTION_CLOSED, demonstrating that the bartering is currently shut. PVoffer and BUYoffer are the ideas from dealers/purchasers (which are characterized under Exchanges, talked about straightaway). To put it plainly, this advantage accumulates the ideas to sell overabundance energy (kWh) from all prosumers in an area at a specific hour, just as assembles the offers to purchase excess electricity from buyers at that hour.

C. Transactions

To facilitate the transaction of the excess energy four types of the transactions are used that are ‘AcceptOfferBroadcast’, ‘PVoffer’, ‘BUYoffer’ and ‘CloseBidding’. Every exchange needs the 'listingid' parameter, which indicates the date and time of power trade.

AcceptOfferBroadcast: This is the communicated message sent to all members consequently in the start of every hour. This message illuminates all participants that the framework is currently open to acknowledge offers to purchase/sell abundance PV energy.

PVOffer: After accepting the communicate message, prosumers can send the ideas to sell their overabundance power ('kWhavailable', kWh) with a discretionary save value ('reservePrice', token/kWh).

BUYOffer: Once getting the communicate message, purchasers can send the offers to purchase excess energy determining the measure of electricity required ('kWhQuantity', kWh) and the value they are eager to pay ('BidPrice', token/kWh).

CloseBidding: The type of transaction indicates that the offering period is presently shut, and the structured smart contract is currently started to process the PV exchange among the participants.

An example of the energy transaction is illustrated in the figure: 2. Assuming that the planned trade of overabundance PV energy is between 13:00-14:00 on Mar 21, the 'AcceptOfferBroadcast' message is conveyed to all members at 12:01, showing that the framework currently acknowledges purchase/sell offers. Whenever somewhere in the range of 12:01 and 12:59, participant can present the ideas to offer their overabundance energy or the offers to purchase PV power for the following hour 13:00-14:00. The 'CloseBidding' exchange is started at 12:59 to clear the market. The real trade of PV power happens between 13:00-14:00, together with the chronicle of real kWh deals and kWh utilization.

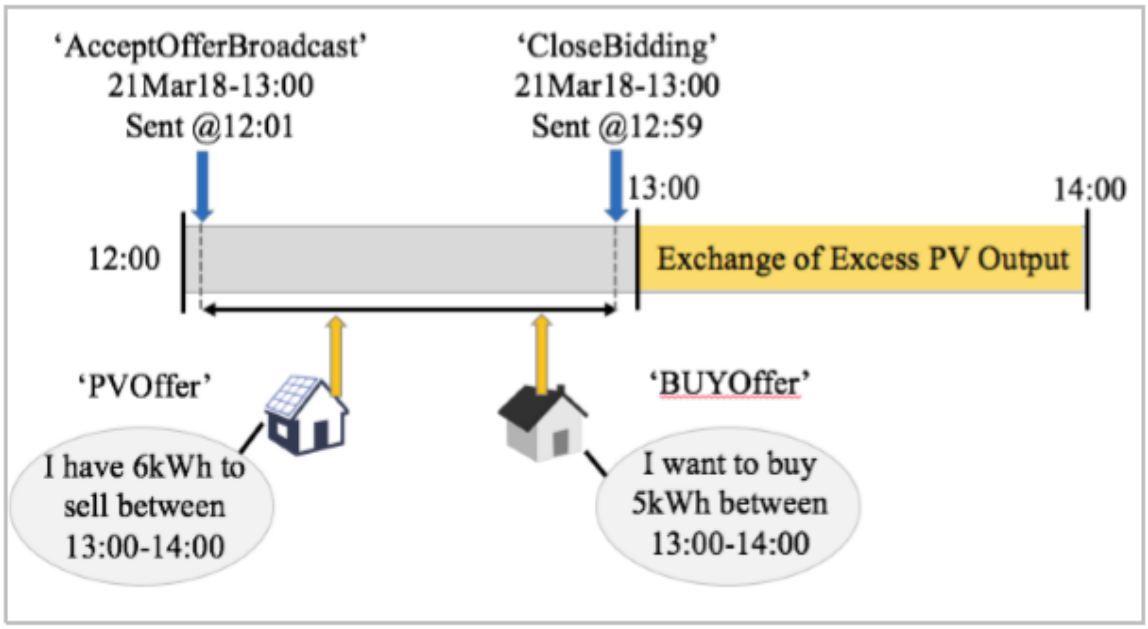


Fig 2. Transaction Example

D. Smart Contract

The smart contract characterizes how the market is cleared considering different ideas to purchase/sell excess energy. The smart contract code is implanted in the 'CloseBidding' exchange, and is considered when the 'CloseBidding' exchange is started. Right now, basic smart contract is executed, and its flowchart is delineated in Fig. 3.

At the instant CloseBidding transaction is executed offers are settled between prosumer and customer. PVOffers are arranged by their offer time recorded in the framework. BUYOffers are arranged from high to low as per the increase of the offer cost (token/kWh) and the amount to buy (kWh).

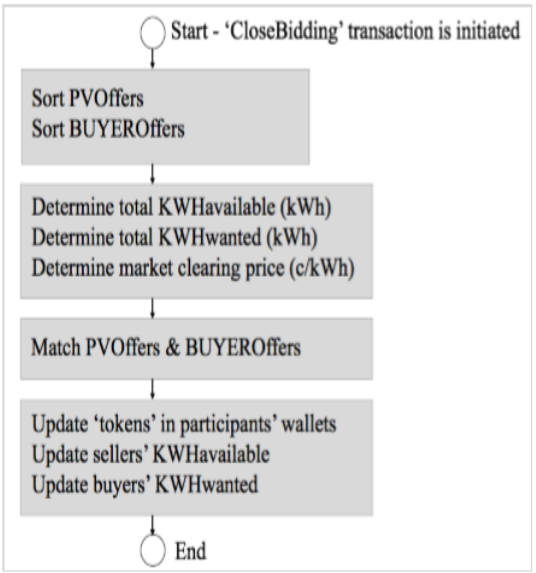


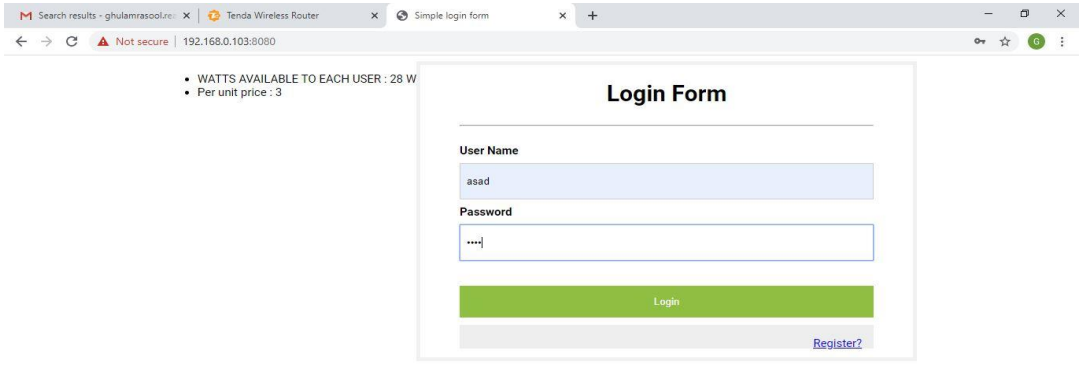
Fig 3. Flowchart of the Smart Contract

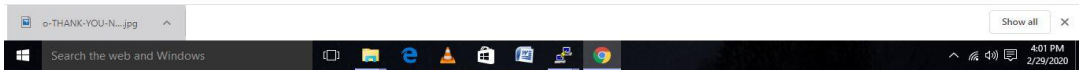
BLOCKCHAIN IMPLEMENTATION USING PYTHON

In this part we will discuss the basic development of the blockchain using python. This blockchain have the ability to add various nodes, there is possibility to resolve the conflict between the connected nodes, it implies the proof-of-work and the encryption to the transaction are achieved using the RSA encryption. We have developed two dashboards one for miners called “Blockchain Frontend” and other for users as they can generate wallets and become able to send coins. These two dashboards are developed using JS/CSS/HTML.

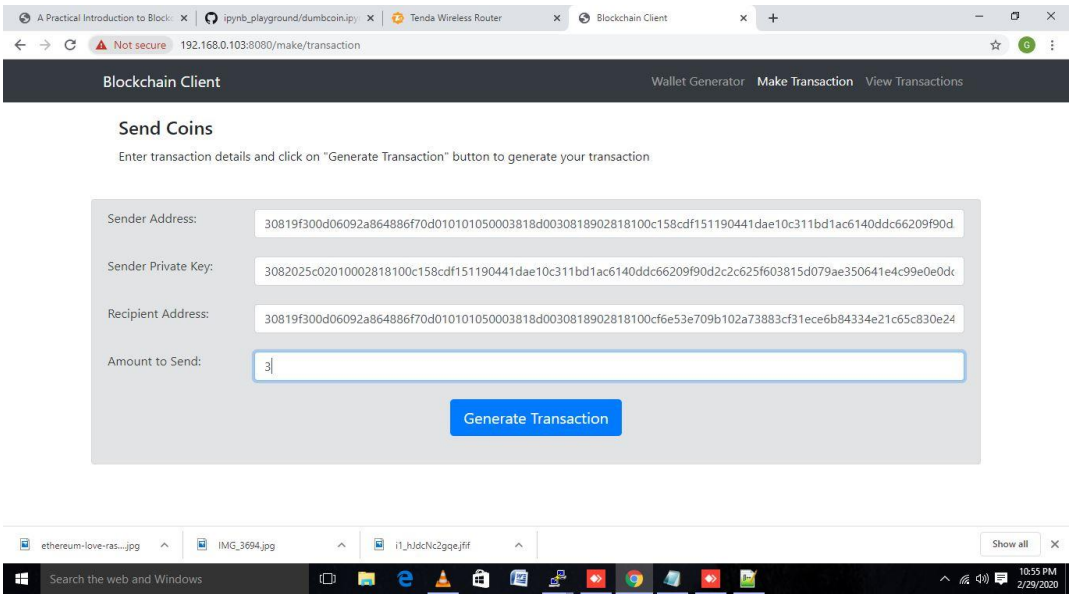
RESULTS

The implemented blockchain results are discussed in this chapter along with the stepwise transaction that has to be take place in the trade of the electricity. For the sake of simplicity we have set one unit of electricity as 19w per minute (19wpm) and per unit costs 3 rupees. Total available watts for each user are up to 28w.

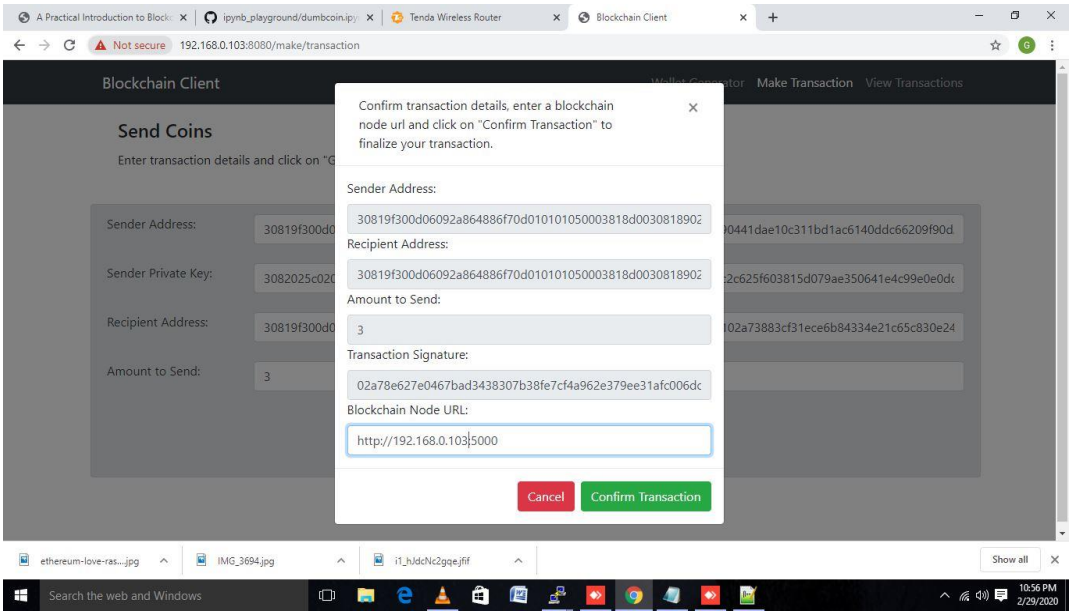




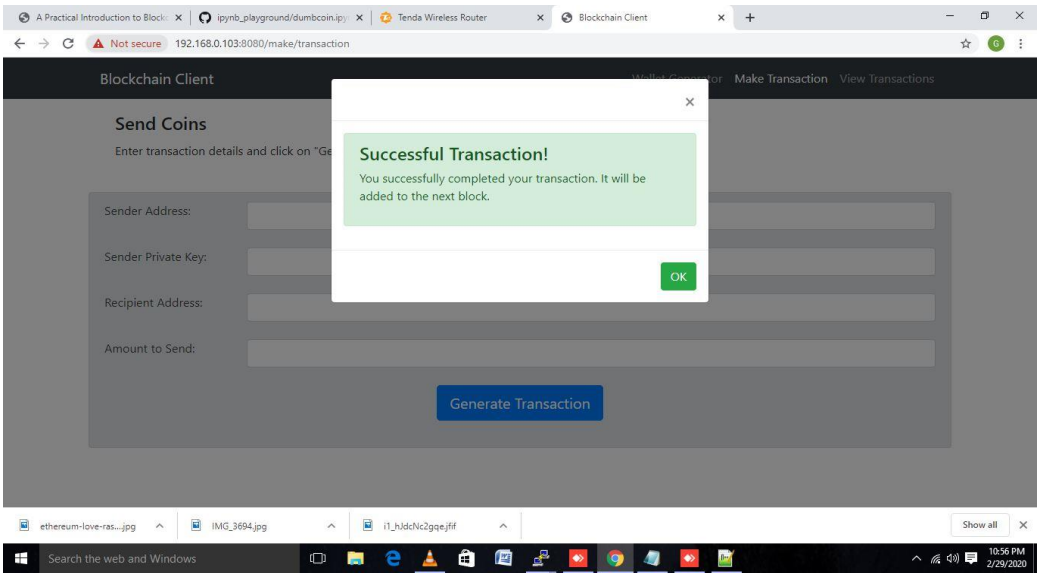
The above dashboard is the first step of the transaction where a buyer can find the watts available and per unit cost. It is the login form where our first user that is Mr Asad login his account using his personal password.



The next step shows Mr. Asad's account where he makes transaction. The sender address is basically Asad's public key along with his private key, recipients address is the public key of the prosumer that is Mr. Zarak in this case, Asad is buying one unit from zarak and writing 3 rupees in the amount to send box and then he generates the transaction.

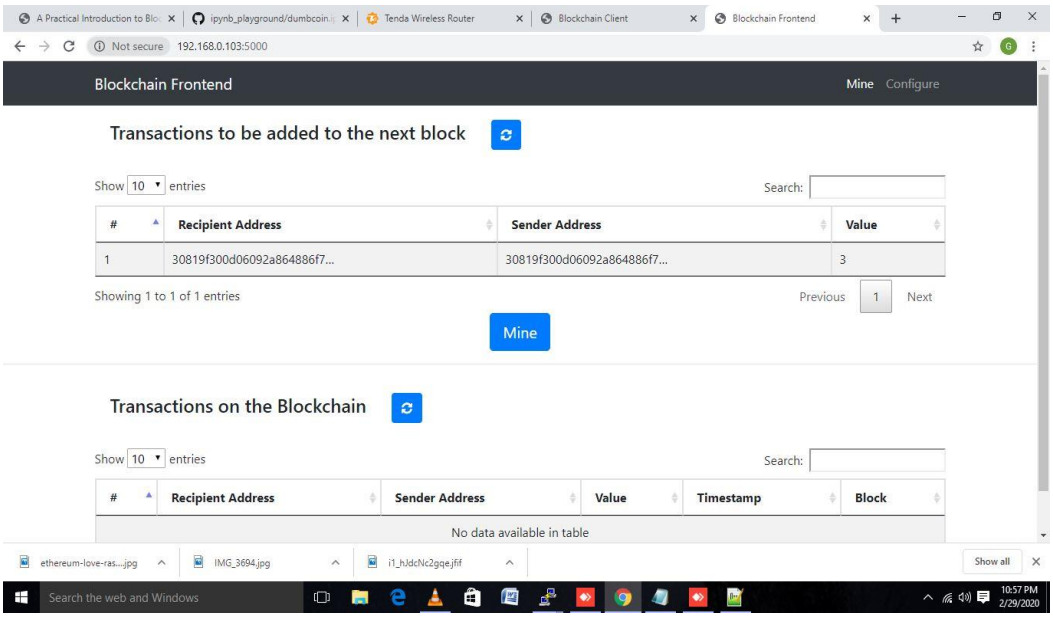


After generating the transaction he receives a confirm transaction massage where sender address, recipient address, amount to send, transaction signature and URL can easily be checked and verified. After confirming all of them transaction can be confirmed.

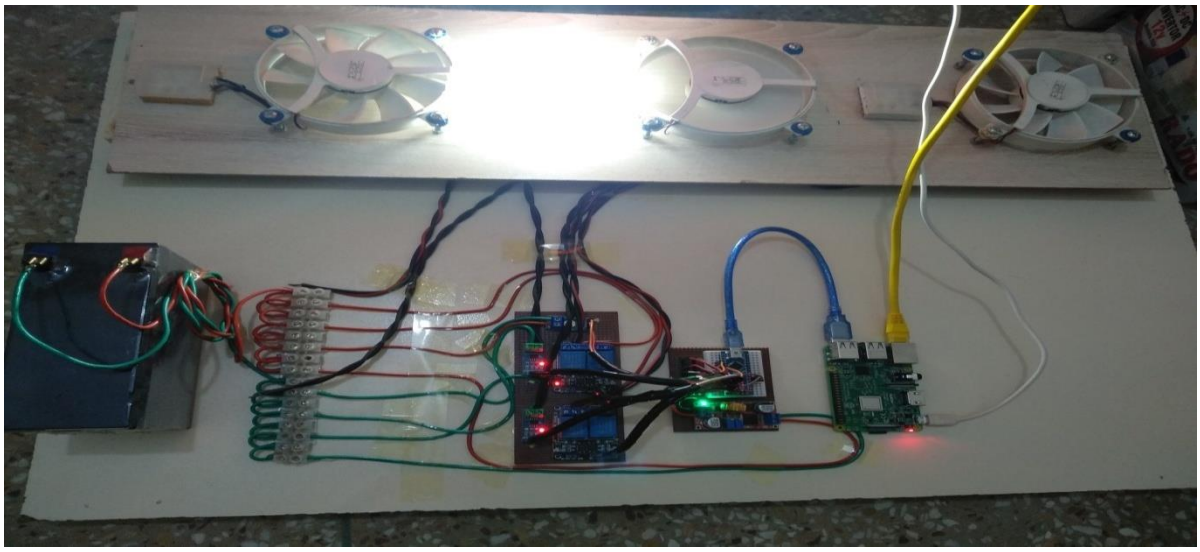


The transaction is successfully done by the buyer and now its turn of the prosumer to allow one unit electricity to Mr. Asad.

The prosumer writes IP 192.168.0.103:5000 and his login account and password to enter in to the Blockchain Frontend where he could see amount that he has received form a customer and mine it in order to share the electricity units that a customer requests for.



In this dashboard we can see value that zarak has received is 3 rupees along with sender's address that is his public key. After clicking on the mine the customer starts receiving the electricity for the time period of one minute. This first transaction is added to the first block of the blockchain and transactions are made more blocks are created and added to each other.



After the successful completion of first transaction we can see the load of Mr. Asad's house (in the center of the others loads) is receiving electricity for the time period of one minute because he has paid amount of three rupees that is the cost of one unit in our case.

CONCLUSION:

Flow innovative advancements enable prosumers to deliver electrical energy in-house or in a neighborhood efficient power energy network; nonetheless, the energy advertise is yet ruled by huge energy players. This implies as of not long ago, most of prosumers approach the (energy) advertise just by utilizing respective understandings. This reality has, up until this point, vigorously affected the genuine dispersion of miniaturized scale age because of the constrained monetary favorable circumstances the energy age approach brings to the prosumers.

This project report exhibits a prosumers energy model so as to think about the achievability of conveying an in-house small scale energy arrangement empowering the energy trade at a network level utilizing on the problematic possibilities of blockchain advancements. The proposed framework depends on a sun based energy dispersion framework that is operated on a blockchain stage called Ethereum.

Some of the advantages are as under:

- It permits the prosumers to be really connected within the energy advertise going about as empowering agent for the production of energy networks.
- It vows to open-up a completely new arrangement of business openings over the idea of energy network.
- It upgrades the straightforwardness and trust of the energy showcase framework.
- It ensures responsibility while safeguarding protection necessities.
- It ensures an elevated level of security, trustworthiness and versatility on account of the inherent idea of blockchain technology.

FUTURE RECOMMENDATIONS

We as of now visualize upgrades for our energy model and will bit by bit seek after them for the upcoming period of the usage. We intend to ponder the viability of the framework when utilized in a business mode that is interconnection with a genuine market energy stage. The plan of action of the framework must be considered well so as to actualize a final result that can be utilized in a genuine situation.
Other than this we will go through some real important parameters that could have a real influence on this energy trading model like as:

- Improving trust in the framework by utilizing trusted platform module empowered smart meters.
- Enhancing frameworks estimations unwavering quality by presenting an agreement component over the proposed design.
- Looking in detail about the security and protection issues introduced in this report of prosumer model.
- Expand the present execution of smart agreement or contract with progressively complex capacities and permit the utilization of coins from outsiders, programmed control of exchange expenses from every participant's record, and a business opportunity for trading HECs.

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