

RESEARCH ARTICLE

Engineering

Design of Energy Transitive Platform Based On Smart Grid Via Blockchain

Diseño de Plataforma Transitiva de Energía Basada en Smart Grid Vía Blockchain

Jeffery Ali Rizvi  1* | Ibrar UI Haque  1* | Jawad Ali Arshad 

1* | Fawadul Haq  1* | Imran Aziz  1*

¹Department of Electrical Engineering Sir Syed University of Engineering & Technology, Karachi, Pakistan.

Correspondence

Jaffery Ali Rizvi

Email: jarizvi@ssuetkhi.onmicrosoft.com

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Abstract. In this paper, we present our research, where residents purchase and sell locally produced renewable energy from each other. In this research work, we integrate block chain technology to create peer-to-peer market-places for distributed energy. First, we use a smart energy meter to measure various important parameters of electrical energy. In this proposed work, the initial measurements of the current are being performed with the help of hall effect sensor due to its accuracy. Second, supply voltage is calculated with the help of a transformer and DC biasing method. The apparent power is calculated by multiplying the measured current and voltage, and then the energy parameter is obtained. Using this smart energy meter, we obtain our desired parameters with sufficient accuracy of nearly 90 percent. These obtained parameters and results are directly uploaded to Amazon Web Server(AWS). We also develop an android app that connects with the AWS server. The designed system facilitates the users to perceive these electrical parameters on meter having built-in LCD display which shows all measured results including a number of units consumed, and billing information anywhere around the world. Finally, we develop a smart contract on Ethereum block chain which can transact the number of tokens according to the units sold or purchased by the users. The Consumer can set their selling rate through the app. Any user with this app is able to take their readings live to their smart phone.

Keywords: renewable energy sources(RES), net metering system, smart energy meter, block chain technology, peer-to-peer(P2P) energy trading.

Resumen

En este documento, presentamos nuestra investigación, donde los residentes compran y venden energía renovable producida localmente entre sí. En este trabajo integramos tecnología de cadena de bloques para crear mercados de igual a igual para energía distribuida. Primero, usamos un medidor de energía inteligente para

* Equally contributing authors.

medir varios parámetros importantes de la energía eléctrica. Las mediciones iniciales de la corriente se realizan con la ayuda del sensor de efecto hall debido a su precisión. En segundo lugar, la tensión de alimentación se calcula con la ayuda de un transformador y un método de polarización de CC. La potencia aparente se calcula multiplicando la corriente y el voltaje medidos, y luego se obtiene el parámetro de energía. Usando este medidor de energía inteligente, obtenemos nuestros parámetros deseados con una precisión suficiente de casi el 90 por ciento. Estos parámetros y resultados obtenidos se cargan directamente en Amazon Web Server (AWS). También desarrollamos una aplicación para Android que se conecta con el servidor de AWS. El sistema diseñado facilita a los usuarios percibir estos parámetros eléctricos en el medidor que tiene una pantalla LCD incorporada que muestra todos los resultados medidos, incluido el número de unidades consumidas y la información de facturación en cualquier parte del mundo. Finalmente, desarrollamos un contrato inteligente en la cadena de bloques de Ethereum que puede negociar la cantidad de tokens de acuerdo con las unidades vendidas o compradas por los usuarios. El Consumidor puede establecer su tarifa de venta a través de la aplicación. Cualquier usuario con esta aplicación puede llevar sus lecturas en vivo a su teléfono inteligente.

Palabras clave: fuentes de energía renovables (RES), sistema de medición neta, medidor de energía inteligente, tecnología de cadena de bloques, comercio de energía entre pares (P2P).

1 | INTRODUCTION

Generating electrical power has turned into a street blocker for economic benefit and growth [1]. As we realize that the electrical power makers in Pakistan have a troublesome framework. The broad use of electrical power has resulted in a crisis, and there is a need to create techniques for ideal usage. Until today, fossil fuel has been main source of generation of electrical power. Using of non-renewable energy sources directly causes environmental declination and the long transmission lines reason being real-time interspacing amongst generating units of electricity and utilization of them also causes energy losses [2]. Our project allows candidates of lower magnitude that being end user and prosumers (a user who can also generate), to assiduously commerce energy with each other in (just about) factual time. It can promote a solid, manageable, consistent hence a nearby equivalency of production and utilization. Therefore, this seems a reasonable and feasible alternative for blending

dispersal renewable energy source(RES) to contemporaneous energy modules in a inexpensive way. In addition, this permits low magnitude energy users and prosumers are provoked to self-finance in regional generation, and aids to start with micro grids that are self-governed networks.

The execution of project demands creative, protected, and modish data framework, that also being a major element for their accomplished operation Block chains, as evolving information technology, proffers a distribute market ledgers and give straightforward added it an easy to use application which permits energy users to partake in the verdict on which of them will generate their own energy and by assist of which technology it is being generated [3]. These self-sufficient energy producers can likewise build the steady quality of supply since it is bundled up with rendering energy in event of supply failure from the respective grid [4].

This concept has gained a lot of interest of several researchers in recent past years, numerous research on Peer to Peer(P2P) energy trade of are pulled off. Such as

“Piclo”, which being setup in UK. It was based as a joint venture amongst a creative technology company namely “Open Utility” and renewable distributor “Good Energy”, featured for consumers to purchase energy at hand from the domestic renewables [5]. Our project is well inspired by LO3 energy(an organization providing energy solutions), the very first peer to peer merchandising made in history of Brooklyn, NY. LO3 launched Brooklyn micro grid where proximate inhabitants were tied up over prevailing grid substructure and delimited P2P energy transactions were pioneered and archived as first execution [6]. Bitcoin is known to originated from the concept of blockchain, however beyond its usage in the transactions modifications has also change the way in which data and information are utilized [7]. As per environmental pliability benefits, distributed energy resources (DER) remains a potential solution in order to meet forthcoming electricity demand, a hurdle is to integrate it with centralized power markets on the large scale, which is a tough call. Practitioners claim that

blockchain technology can generate a new market structures for DER like local peer-to-peer energy markets which foster renewable generation [8, 9].

Our design consists of a smart energy meter which will be measuring grid's energy and other electrical parameters alongside P2P transaction will be made via blockchain technology by making a smart contract on Ethereum blockchain which can transact the number of tokens according to the units sell or purchased by the users. Consumer can set their selling rate through the app. Any user having this app installed, will take their reading live to their smart phones. Fig. 1 shows the System Flow Diagram.

2 | SYSTEM MODEL

2.1 | Smart energy metering

Local energy producers using renewable energy sources (RES) can earn bill credits for excess power that flows from their system to the electricity grid. This type of transaction is referred to as Net Energy Metering or NEM [10]. In this project we control this process using a smart contract on Ethereum public blockchain.

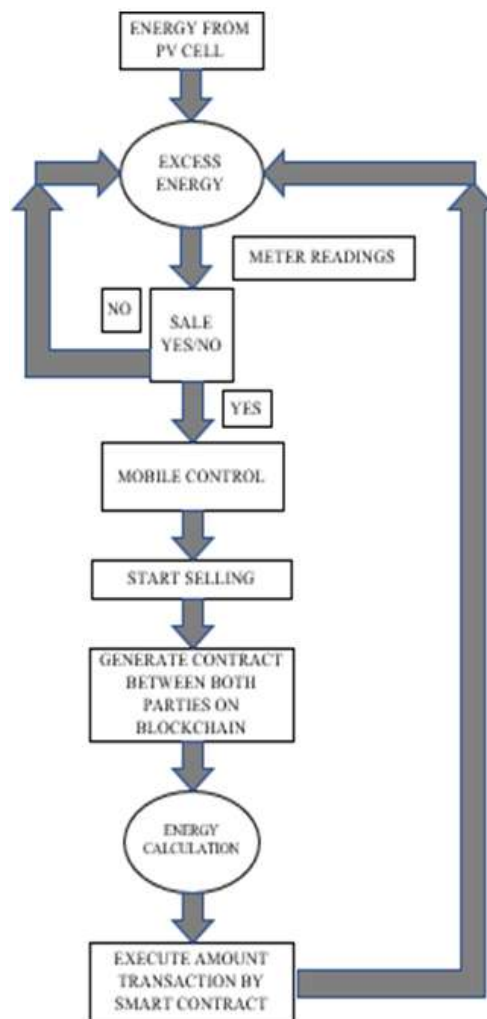


FIG. 1 System flow diagram.

We use an electronic smart energy meter, their work is quite simple they have voltage and current sensors

which senses voltage and current and send the appropriate signal to microcontroller which calculates power and energy by summation of all the readings of power flow [11]. This approach is quite handy and economical for both the consumer and electric supply company. The main objective of smart energy meter is given below:

- To display current, voltage, power and energy.
- efficient and user friendly.
- wireless meter reading.
- display results in a smartphone through an android application.
- Low Operating Cost and Production Cost is Reduced.

Our project is related to this which covers all the objectives which are listed above as well as we give new dimensions to trade energy with each other via smart contract using block chain technology. As we step into age of modernization and artificial intelligence the need for self-governed electricity and consumption is at verge of execution by such means as highlighted in the proposed work. It was the need of hour to come up with such proposal [12].

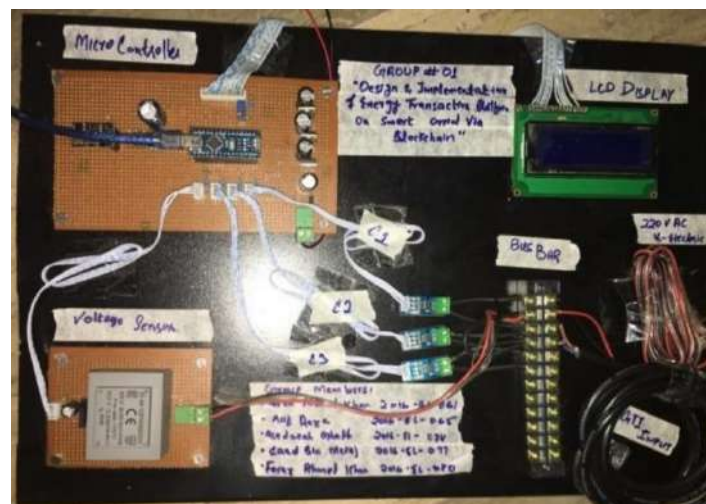


FIG. 2 System flow diagram.

Following are the main components and functions used in our smart meter:

(i) **Current sensor ACS712.** For measuring current we use ACS712 sensor which principally operates on Hall Effect whenever current enters to it gives proportional voltage signal to its output terminals between 0 to 5 volts.

(ii) **PT Transformer.** we use PT transformer to stepdown 220 volts AC (from electricity company) into 12 volts AC.

(iii) **Bridge rectifiers and capacitors.** They help us to convert 12 volts AC (from the PT transformer) into DC volts. And to reduce noises [13, 14].

(iv) **Arduino Nano.** In our project we use Arduino Nano board because of its small size, cheap price and several analog pins, digital input / output pins, six analog inputs, 6 PWM pins and 16Mhz clock, universal serial bus connection, added with it a power jack, in addition a ICSP header concluded with a reset button. It has everything expected to help the microcontroller.

(vi) **Measures Power.** Power can easily be measure simply by taking product of sensor values of current and voltages.

(vii) **Calculate Energy.** Energy is calculated by taking product of power and time.

(viii) **Show Your Bill.** Bill can be calculated by taking product of energy and price of single unit.

(ix) **Large Led Display.** which shows all parameters and readings Output of all the parameters is updated on every second and shown on led which has 16*4 large display.

(ix) **W1-Fi Connectivity.** It has Wi-Fi connectivity which to transfer all of user's data to cloud which Shows result on android mobile app we have design an android app for monitoring and controlling of transactions of tokens. Prototype of Smart Energy meter is depicted in Fig. 2.

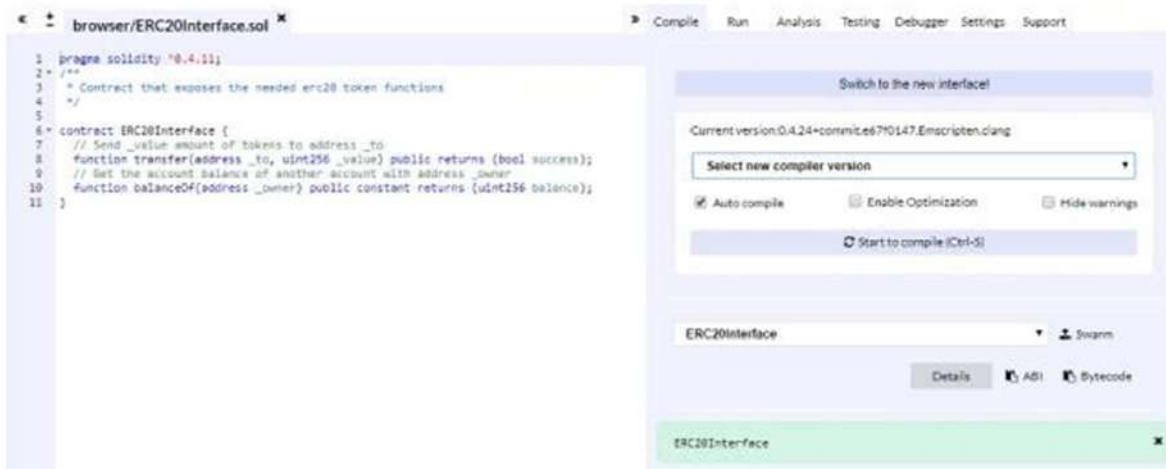


FIG. 3 Compiling & deployment of smart contract on Ethereum.

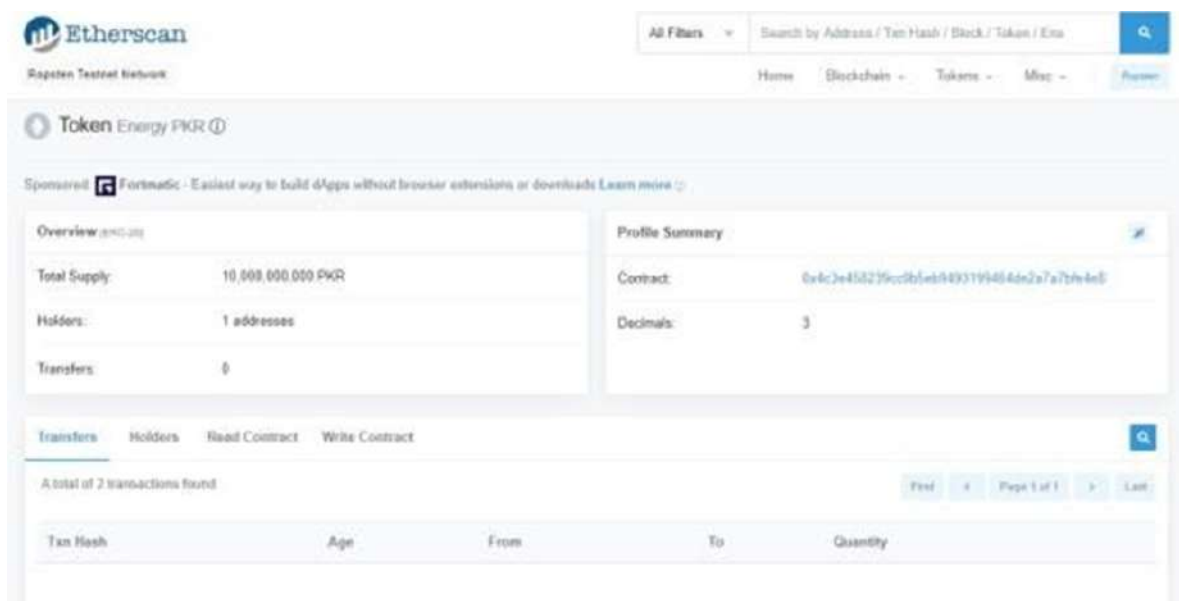


FIG. 4 Transactions of trades whether he was selling or purchasing (executed by the smart contract)[15].

2.2 | Developing a Smart Contract

We use Ethereum Public Block Chain Network for the deployment of smart contract. We develop the Ethereum smart contract in Solidity programming language. We create a smart contract which ensure to transact tokens to seller automatically from buyer's wallet when it fulfills the condition of transferring the electricity. Smart Contract will be checking every five minutes that how much the amount of electricity unit supplied to the buyer and according to the unit rate settled between the buyer and seller from our android trading app. The Smart contract perform the transaction of tokens which deduct amount of token from the buyer's wallet and send it to seller's wallet.

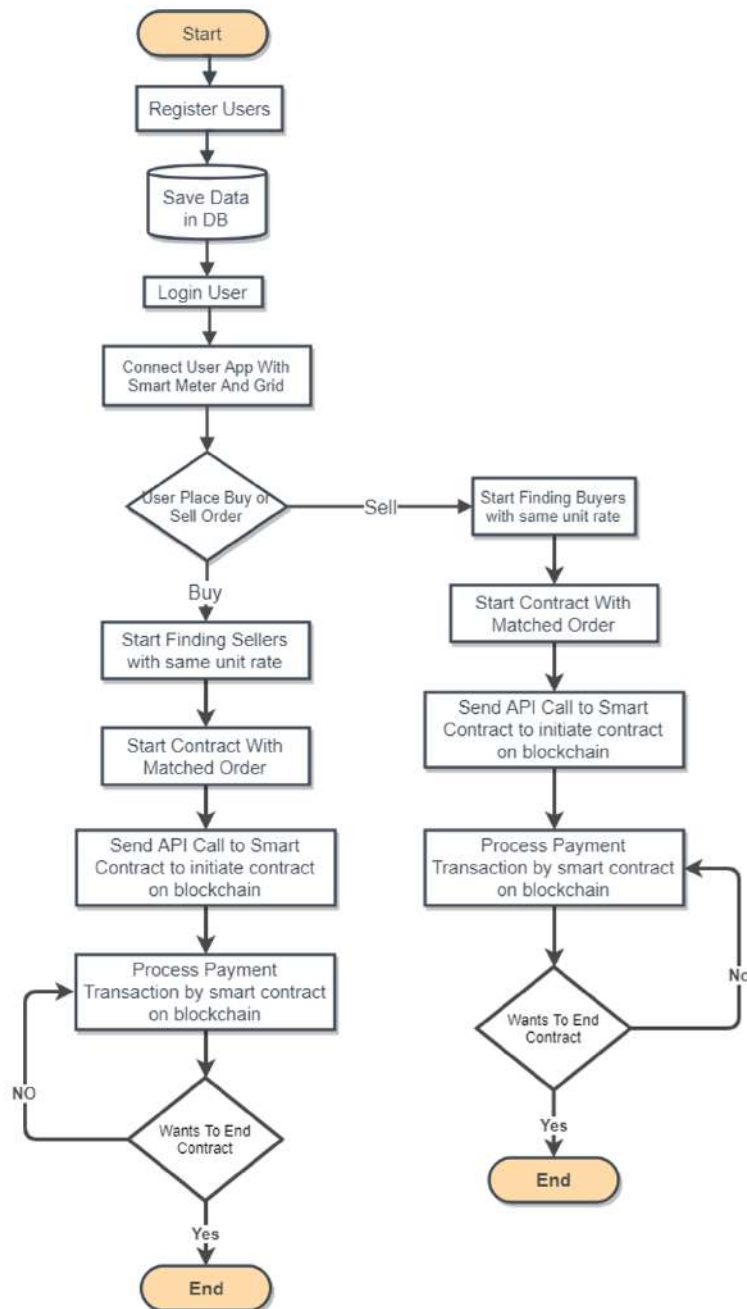


FIG. 5 Flow Chart of Android Application.

Smart contract also checks the balance of buyer's if they have insufficient balance then they cannot buy electricity from any of the available seller. The token is named as PKR and one token is equal value of one PKR. The compilation & development of Smart contact Ethereum is shown in shown in Fig. 3.

2.3 | Application development

We develop our android application using the flutter framework and Dart as programming language, selection of flutter is because it creates natively compiled apps for android, web and IOS from a single codebase and it helps to build an optimized app and give a native performance on both IOS and android. Also we use MySQL for the database [16]. We create a registration form in our app to register the consumers or prosumers of society, members can register in our app by filling form details and residential proof document In registration page we collect user's basic information and provides an option to select a society where he's living and after completion of form we save their data on our database in encrypted form. Then appears a login page where user can enter in their dashboard to see all the records. This page shows all electricity stats coming from the smart meter (streaming data using ESP8266) in Stats page of app. We distributed the dashboard in three sections:

2.3.1 | Trading Panel

We design a trading panel where a buyer can see list of seller, if consumer decided to purchase electricity from any prosumer, then he can easily select any seller who is selling electricity in good rates from the list of available sellers. The consumer can only purchase electricity if he has enough balance in his wallet and after that he can use that electricity and this app also provides access to user to cancel the trade at any time and start trading from any other reasonable prosumer[17].

2.3.2 | Wallet

The model pattern for exchange & trade of energy is made accessible for all whether it be the dwelled individuals or workers from various fields, or even organization can take use of it. In wallet section user can see his balance and he will have option to deposit the token or withdraw the token from our application. Energy token transaction page is replicated in Fig. 4. In wallet section user can also check all the previous deposits and withdrawals transactions [18].

2.3.3 | Stats

In stats section user can see all stats of consumption of electricity. In trade page we provide an option to users for adding their order of buying or selling their renewable (RES) electrical energy, when any order is matched, it send API call to the function of smart contract to start the contract between two parties and after the contract starts, it transfers data of trading energy to smart contract using Smart Contract API that will execute the token transaction from buyer to seller. We save all data of trade orders, executed trades, active trades and token transaction in our database and user also can see all his history from app Log Page. The final flow chart of android application is depicted in Fig. 5.

3 | RESULTS

It has been found that while testing this project, Energy generated from PV cell or any other Renewable energy sources (RES) can be traded with one another via smart contract on blockchain. The electrical energy produced by the PV cell is utilized by the prosumer and also the excess amount of energy is traded with the consumer. A smart contract is created which ensure token transaction between prosumer and consumer by using a Ethereum public blockchain network.

4 | CONCLUSIONS

Our project regarding the Metering system where we had renewable energy and we used it in a very efficient way. The Renewable energy is first used for your own energy consumption but if there is any extra energy left, that energy is not wasted but it is used by sending it back to the grid/any other consumer. As a result you get the credit for those units which you have sold to the consumer. This all system is accessed through a android application which is connected with the Ethereum public blockchain network which is accessed worldwide. So if you are anywhere around the world you can check your energy bill and sell your extra renewable energy and control it. The android application designed for this system is very easy to use. It has a simple dashboard which is distributed in a trading panel, wallet and stats and one can easily understand and control the whole system. Real time access, high accuracy class and easy energy management through android application are some of its features which makes it far better than the energy meters used conventionally nowadays.

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