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Block Chain Technology Based a Secure Solar Energy Management and Trading System

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Abstract*: With Block-chain based functions in the electricity marketplace are new to the solar energy business as well as an adolescent area within intellectual research. Researchers up to now have analyzed how the block-chain technology can upkeep the energy management and trading of the distribution network and within housing micro-grids while integrating distributed solar energy. In this paper, block chain technsology based solar energy management and trading is proposed to manage the generated solar energy using PV array. Solar energy management during its distribution and conservation phases is one of the major issues characterizing in this innovative world and that claims for the design of novel energy management solutions. Achieving high efficiency in the energy management system is crucial to electronic devices. We have analyzed our proposed model for solar energy management and trading is a better option to prevent the management system where solar energy is generated in a large amount using the PV array. Illustrative results point toward the proposed solar energy management and trading system effectively improves the system performance in terms of QoS parameters. Based on the observations of results, we can conclude that the energy distribution time of the proposed system is fast and also work for a high amount of energy.

***Index Terms*: Block-chain Technology (BCT), Solar Energy, Photovoltaic (PV) Cell, PV Array, Energy management and trading system, Quality of Service (QoS)**

I. INTRODUCTION

With the fast improvement of practical vitality innovations and system advancements, the Solar Energy Management [1] spoken to by "New Solar Energy + Management" has turned into the new wilderness of mechanical development in the global vitality the scholarly world and industry [2]. Besides, it is too a significant improvement course in the field of vitality after the brilliant lattice [3]. Up to this point, investigate on the Energy Internet is still at the dimension of hypothetical research and engineering structure. The Energy Internet that is really running is as yet uncommon [4].

On the word of scientific findings, the earth interrupts lots of solar power, 173 trillion terawatts to be specific. That's literally ten thousand more power than the entire world population utilizes. This validates the fact that the sun is the most plentiful source of energy on the entire globe and that it could be one day the most reliant source of energy [5]. Traditionally, the world's electrical needs have been fulfilled by fossil fuels like oil, natural gas, and coal. However, these energy sources have two main negative impacts: They play a bigger role in global warming and acid rain pollution, which negatively impacts many animals, plants, and humans in the environment [6]. Few countries have full access to fossil fuel-based energy resources, which can lead to global political and economic instability [7]. The best alternative is solar energy, which is a renewable resource, meaning it will not become unavailable. It provides an unlimited, steady supply through time. Solar energy is also a green source of energy because it does not emit pollutants during the energy production process. The most challenging issues in the field of Block-chain Technology (BCT) based solar energy management and trading [8]-[12].

Confidentiality: The principle of confidentiality specifies that only the sender and the intended recipient should be able to access the contents of a message.

Authentication: Authentication mechanisms aid to establish evidence of identities. This procedure confirms that the origin of the message is properly identified.

Integrity: The integrity mechanism confirms that the subjects of the message remain similar when it touches the intended recipient as sent by the sender [13].

Non-repudiation: Non-repudiation doesn't sanction the sender of a message to negate the claim of not sending the message.

Access Control: Access Control specifies and controls who can access what.

Availability: The principle of availability states that resources should be available to authorized parties all the times.

The contribution of proposed block chain technology based solar energy management and trading system will help to develop a secure model for energy distribution [14]. The main contribution of this research work is identified as follows:

- ❖ Create an optimize blocks for peer-to-peer management and trading of solar energy with data encryption technology [15].
- ❖ For maintenance of the management and trading system in a large amount of solar energy, we design novel technology architecture using the concept of block chain.
- ❖ We evaluate performance parameters of proposed research work, energy and time for required management and trading are calculated [16].

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This paper, presents a model using block chain technology based a secure solar energy management and trading system. Specifically, in section 2, we present the literate survey (background survey) of existing work for energy management and trading. The architecture of the proposed work is described in section 3. The simulation result is cover in section 4 and we conclude with discussions on current challenges and future trends in section 5.

II. BACKGROUND SURVEY

In this section, we present the survey of existing work based on energy management and trading using different algorithms and techniques. Jiani Wu and Nguyen Khoi Tran [1] discussed the application of block chain technology in sustainable energy systems. They proposed the development of block chain and the Energy Internet, and provide some references for the possible applications of block chain technology to the Energy Internet. Firstly, the definition and characteristics of block chain and the Energy Internet are introduced in detail. Secondly, the compatibility of the two is analyzed. Then, several application scenarios of block chain in the Energy Internet are put forward. So from this paper, the used of block chain technology is the newest and modern technology for the management and trading of solar energy. Alisa Orlov [2], presents a research work which goals to find the business proto types utilized by block chain-based initiatives as well as projects in the electricity market and find how they affect it. This study surveys the market trends in the electricity market besides general socioeconomic and technological improvements. They add worth to both the research and the practice in three ways. First, it aids considerations about block chains in the electricity market and their practical utilize. Second, it sheds sunlit on the implications of their utilization on the electricity market and its partakers. Third, it places of interest what factors essential to be deliberated when implementing a block chain based P2P energy-trading stand. Alan Cohn, Travis West, and Chelsea Parker [3] present shrewd all things considered: block chain, brilliant contracts, and parametric protection and savvy vitality matrices. Inside the vitality business, block chain-based shrewd contracts can further empower the reception of miniaturized scale lattices and innovation, for example, savvy meters, which can extend availability to various models of electric power circulation and give flexibility against inadvertent or conscious disturbance. Along these lines, block chain based shrewd contracts can possibly both streamline and increment the proficiency of existing procedures and open new models of administration conveyance. Pietro Danzi, Marko Angjelichinoski, et al. [4] they proposed Distributed Proportional-Fairness Control in Micro Grids by means of Block chain Smart Contracts. In this exploration work, creators created relative decency MG control and set up an examination between the standard unified designs and block chain-based one, confirming that the block chain-based arrangement can repeat the control destinations of the brought together engineering. The structure of block chain convention custom fitted for MG applications is a piece of our progressing research. DejanIlic, Per Goncalves Da Silva, et al. [5] they proposed a vitality showcase for exchanging power savvy network neighborhoods. In nearby commercial centers buyers and makers can draw in into vitality exchanging for their neighborhood, while a few partners may appreciate the created advantages. The endeavors to structure and actualize such a nearby commercial center and explore its effect have been investigated. The underlying outcomes demonstrate that such a market is a practical methodology. It was seen how the market proficiency and the outright proportion respond to the vitality overflow of its members. F. Imbault, M. Swiatek et al. [6] displayed the green block chain. This examination stays to be done both on the hypothetical establishments of the block chain and on the pertinent business applications for vitality the board. This exploration work investigates the utilization of block chain innovation actualized on an Industrial working framework for a utilization instance of green endorsements, showed inside an eco-locale. Another spotlight of the work is to provide a general idea of the related work in solar energy management and trading, together with the open challenges. From the analysis, we find out the comparison of features, advantages, disadvantages, and application of solar energy management and trading in detail which is explained in tabular form.

Table 1: Comparative Analysis Of BCT Based Solar Energy Management And Trading System

Features	Advantages	Disadvantages	Applications
Block Chain Technology (BCT): It makes like smart by gathering the data using secure networks.	**Increased users engagement:** BCT is used to achieve high accuracy and can be engaged effectively with the users	**Security:** As BCT connects numerous devices connected through the internet thus many external attackers can affect the security of the system.	**Energy Distribution:** In homes, company, office, etc. the users can use electricity without any disturbance.

Connectivity: Practically network of BCT based solar energy management and trading system exists in a small area that is connected between the devices with security.	**Technology optimization:** BCT opens the world of serious functional and field data.	**Privacy:** In BCT based solar energy management and trading system is more secure due to connectivity properties.	**Wearable:** BCT used by wearable devices such as fitness, health, finance, management, and entertainment fields.

Applications of block chain-based in the electricity market are new to the energy business as well as a young zone within academic research. Researchers up to now have analyzed how the block chain technology will aid the energy management and trading of the dispersal. But management and trading of solar energy is the biggest task for researchers because prevention of solar energy from the theft is more difficult and maintenance of record with every time period is also a major problem. The main aim of the work is to find the block chain-based business proto types in the electricity market as well as to evaluate the appropriate business models' worth proposition in lieu of prosumers and consumers. The work explores how the block chain could be executed to facilitate a climate-friendly in addition to the distributed energy system. Against this backdrop, the research described here particularly emphases on the significances to the energy market and their market participants. The electricity structure comprises two constituents: the electricity network as well as an organized electricity market. The electricity network pertains to the flow of electricity. It confirms the power transference as well as is distinguished into a communication and distribution network for elongated and short distances, separately. The electricity market consists of the organizational configuration of the market, its partakers, and their method of communication. During the distribution of electricity, the prevention is the biggest task and in this work, block chain based technology will be utilized to management and trading of solar energy with encryption technique to maintain the records of users. Our model can be easily generalized to other challenging energy management and trading problems and also improve the system efficiency for a large amount of energy generation rate with minimum distribution time of the proposed model.

III. METHODOLOGY STRUCTURE

In this section, the proposed methodology is described for block chain technology based solar energy management and trading system. The procedure of proposed work using the concept of block chain technology, are defined as follows:

STEP 1: To design a framework using the concept of GUI for simulation of proposed block chain technology based solar energy management and trading system. . The area of the proposed model is defined by using the given formula.

Area of Network=Height X Width (1)

Where Height and Width are considered as 1000m so the total area of the network is 1000m2. The designed framework of proposed solar energy management and trading is shown in figure 1.

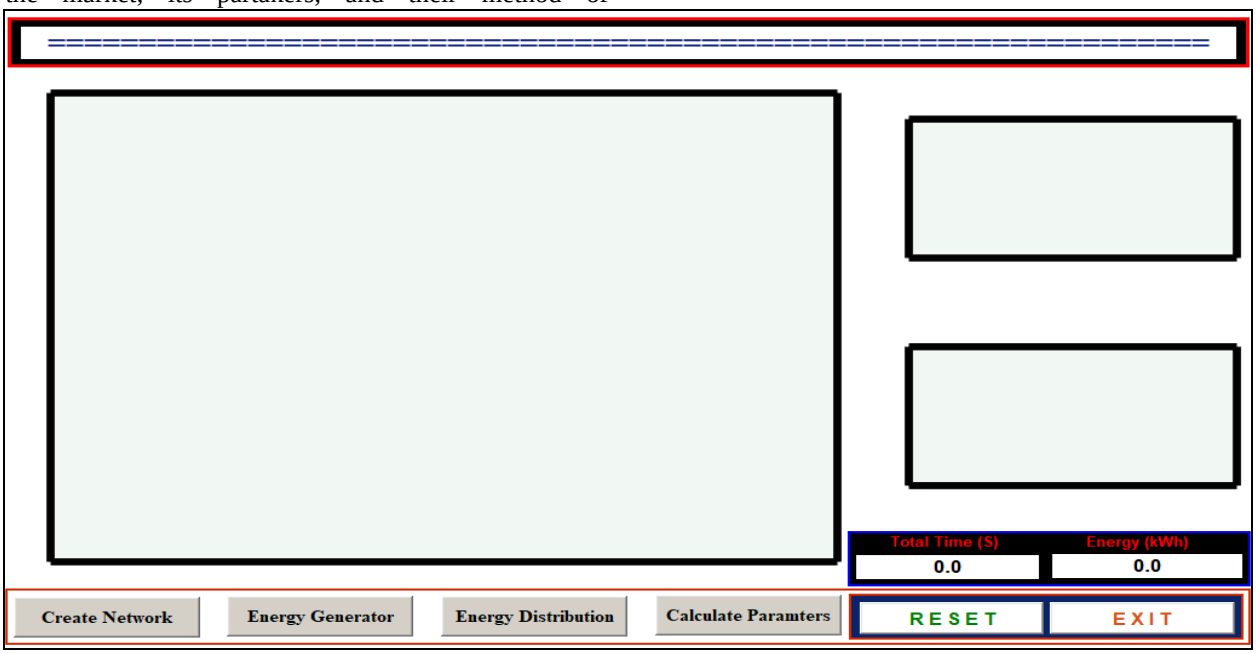

Figure 1: Framework of the proposed model

The above figure represents the simulator window of proposed solar energy management and trading framework with height and width (1000×1000). In the figure, there are two sections first is "Simulation Panel" and second is the "Result Panel". In the "Simulation Panel" we provide the required input data to simulate the designed network and in "Result Panel" we check the performance parameters of proposed work after the simulation of network.

STEP 2: Design a module for the generation of solar energy using the PV cell for the simulation purpose of proposed work with a number of users. The proposed solar energy management and trading framework with 50 users are shown in figure 2.

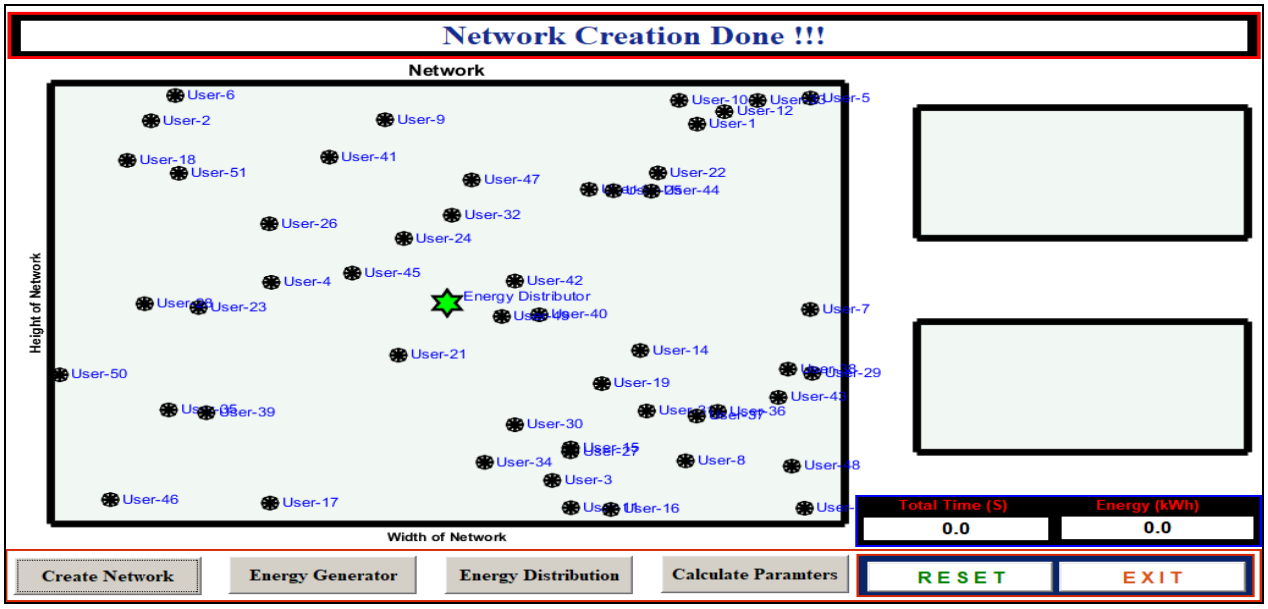

Figure 2: Framework of the proposed model with users

Figure 2 represents the proposed solar energy management and trading framework with 50 users which are marked by black color circular wheel and the energy distributor is situated in the middle of the network with a green color star. For the network deployment, we used a network deployment algorithm and the algorithm is given as:

Algorithm 1: Network Deployment

Input: Number of Users, Height, and Width

Output: Created a network with users and Energy distributor

Define height = 1000

Define width = 1000

Define N number of user for the simulation of the proposed model

1. for i→ 1 to N

2. X (i) = Area X random

3. Y (i) = Area X random

4. Plot_User (i) = coordinate(X, Y, Marker as circular wheel)

5. Define user name = N (i)

6. Define user properties = N (i)

7. Deploy users in the designed network

8. Define Distributor

9. End

10. Return: Created a network with users and Energy distributor

11. End

STEP 3: Generate and store solar energy in terms of electricity and develop a code for the distribution of solar energy with consumers using peer to peer concept. The model with generated solar energy is shown in figure 3.

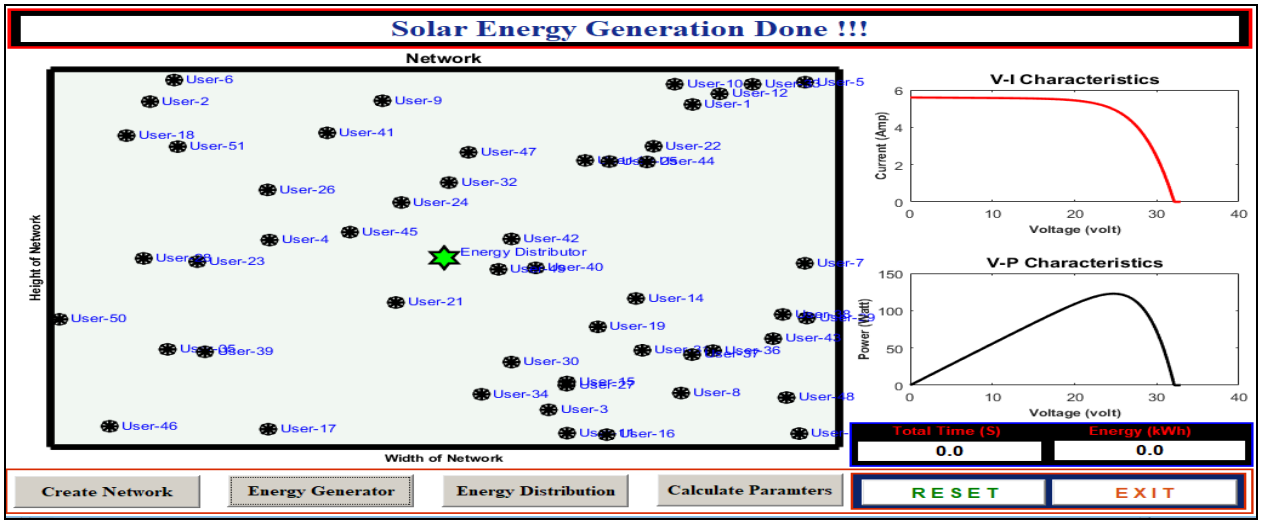

Figure III: Framework of proposed model with generated solar energy

Figure 3 represents the proposed solar energy management and trading framework with solar energy generated by PV array. For the solar energy generation used algorithm is given as:

Algorithm 2: Solar Energy Generation (SEG)

Input: Number of Users with their properties
Output: Generated solar energy

1. for Itr1→Users
2. Define basic constant for solar energy
K=1.38065e-23 // Boltzmann Constant
q=1.602e-19 // Electron's Charge
Iscn=8.21 // Desirable Short Circuit Current
Vocn=32.9 // Desirable Open Circuit Voltage
Kv=-0.123 // Temperature Voltage Constant
Ki=0.0032 // Temperature Current Constant
Ns=54 // Number of Series Connected Cells
T=25+273 // Operating Temperature in Kelvin
Tn=30+273 // Temperature at STC
Gn=1000 // Irradiance at STC
a=2.0 // Diode Ideality Constant [1<a<2]
Eg=1.2 // Band Gap of silicon at Temperature of STC condition [25 deg. Cel]
G=1000*rand // Actual Irradiance
Rs=0.221 // Series Resistance of Equivalent PV cell
Rp=415.405 // Parallel Resistance of Equivalent PV cell

3. $Vtn = Ns * ((K * Tn)/q)$ (2)

4.
$I0n = Iscn/((exp(Vocn/(a * Vtn))) - 1)$
(3)

5.
$I0 = I0n * ((Tn/T)\text{^}3) * exp(((q * Eg/(a * K)) * ((1/Tn) - (1/T))))$
(4)

6. $Ipvn = Iscn$

7.
$Ipv = (G/Gn) * (Ipvn + Ki * (T - Tn));$
(5)

8. $Vt = Ns * ((K * T)/q)$

9. i=1

10. I(1)=0

11. For (V=Vocn to 0 with -0.1 interval)

$I\_term1 = I0 * (exp((V + I(i) * Rs)/(Vt * a)) - 1)$
(6)

$I\_term2 = (V + I(i) * Rs)/Rp$ (7)

$I(i + 1) = Ipv - (I\_term1 + I\_term2)$ (8)

12.if I(i)>0
I(i)=I(i)
13. Else
I(i)=0
14. End

$Pi(i) = V * I(i)$ (9)

Vi(i)=V
i=i+1
15. End
16. End
17. Return: Generated solar energy in terms of Vi, Pi and I
18. End

STEP 4: After the distribution process, apply block chain technology for management and trading of solar energy and record the total distribution of energy. Figure 4 represents the distribution process of solar energy to users.

STEP 5: Identify and update the record of energy consumption according to time and if any irrelevant activity founded then encrypt the user records.

STEP 6: At the last of the simulation, the performance parameters of the proposed work will be calculated in terms of Total energy consumption and total take time by model.

We have calculated the performance of our proposed solar energy management and trading using the block-chain on the basis of the following performance metrics:

1)Solar Energy Consumption: This metric evaluates the solar energy efficiency of our proposed solar energy management and trading using the block-chain. It is calculated as the total energy consumed by users. The formula of solar energy consumption is given as:

$$E_{Con} = \sum_{i=1}^{users} T_{energy} + R_{energy} + W_{energy} \quad (10)$$

Where T_{energy} is the complete energy consumed by the user during the energy transmission, R_{energy} is the total energy consumed by the user during the energy receiving by receiver user and $W_{energy}$is the waiting energy consumption rate which consumed by the user.

2)Time of distribution: The time of distribution value of proposed work is the summation of all types of time consumption during the solar energy transmission or distribution from distributor to users. To calculate the time of distribution of proposed work given equation is used.

$$\mathbf{Timeofdistribution} = \sum_{i=1}^{Users} T_{time} + R_{time} + W_{time} \quad (11)$$

Where T_{time} is the energy transmission time, R_{time} is the energy receiving time and W_{time} is the waiting time by users.

Figure 4 represents the process of solar energy distribution in 50 users using the concept of block-chain. From the figure, the connection between energy distributor and user 5 is marked by red color line, because user-5 wants to fraud in the record of consumed energy list. In this scenario, each user has a hash value and if any user wants to manipulate with a record then the hash value of that user automatically changed. If energy distributor checks the hash value of those users is not matched with the previous one then they consider as a theft user and block their record and the flow chart of the proposed work is shown in figure 5.

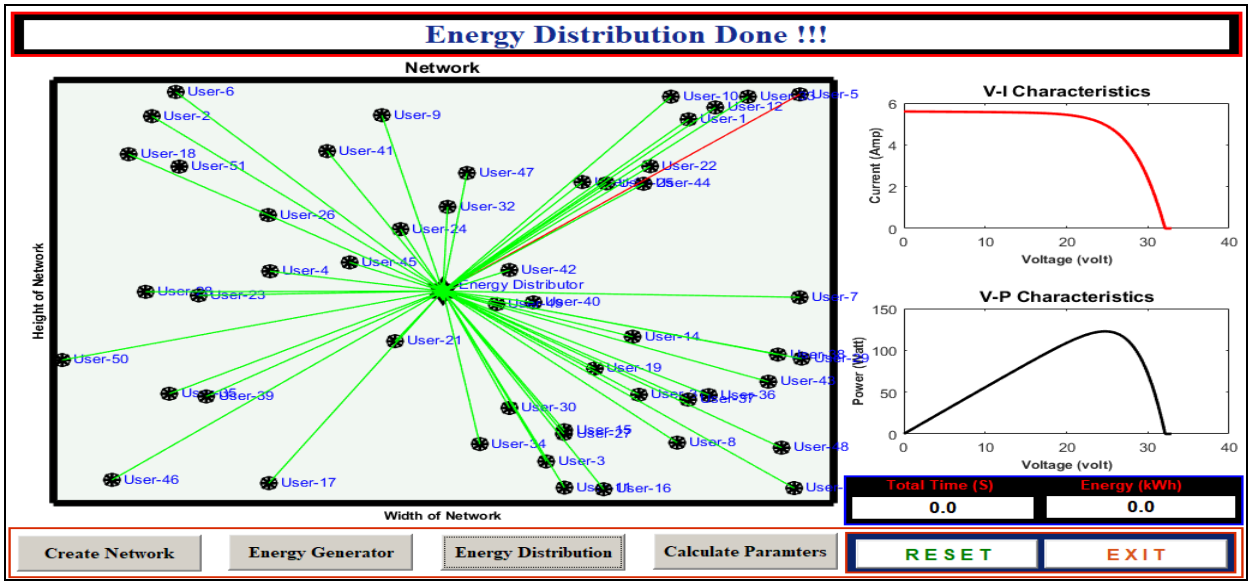

Figure 4: Proposed Framework

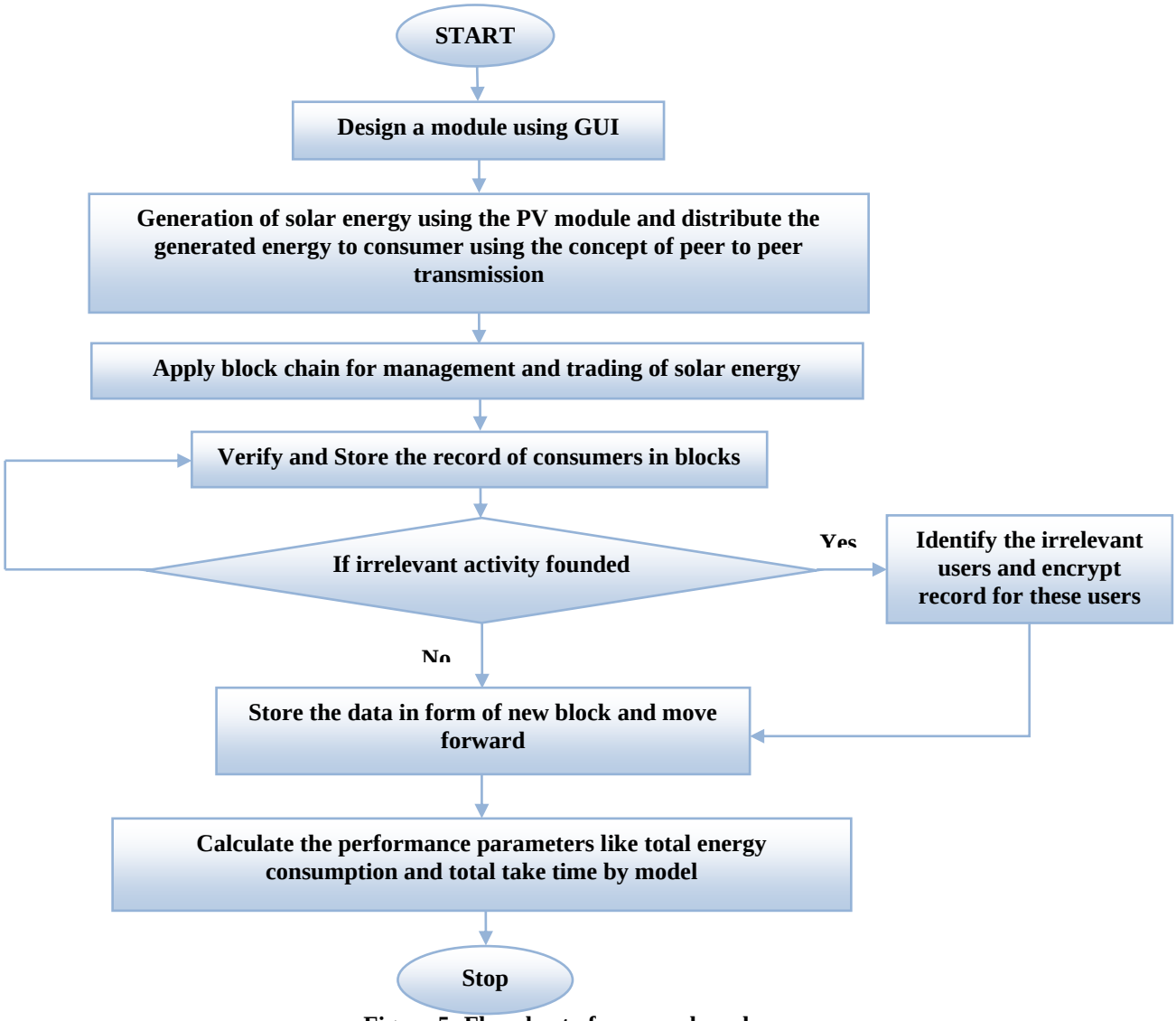

Figure 5: Flowchart of proposed work

IV. RESULTS AND DISCUSSION

In this section, the results attained after as simulating the code in MATLAB environment has been defined. In the proposed research work, block chain technology based solar energy management and trading system is designed.

This section, describe the simulation results of proposed block chain technology based solar energy management and trading system are discussed and the efficiency of proposed work is observed. The simulation environment of the proposed work is shown in the table and the simulation results are described in the below section.

Table 2: Simulation Requirements

Number of Users	**10-100**
Area	**1000m^2**
Simulation Tool	**MATLAB**
Authentication Parameter	**Energy Consumption Record**
Evaluation Parameter	**Energy Conservation and Distribution time**

Table 3: Performance Parameters

No of Rounds	*Time (s)*	*Energy (kWh)*
1	17.8	43423.5
2	14.1	44522.7
3	11.9	42451.3
4	9.2	34521.1
5	9.1	43619.8
6	9.0	45618.3
7	8.9	45617.5
8	8.9	37516.3
9	8.8	34516.3
10	8.8	45516.2

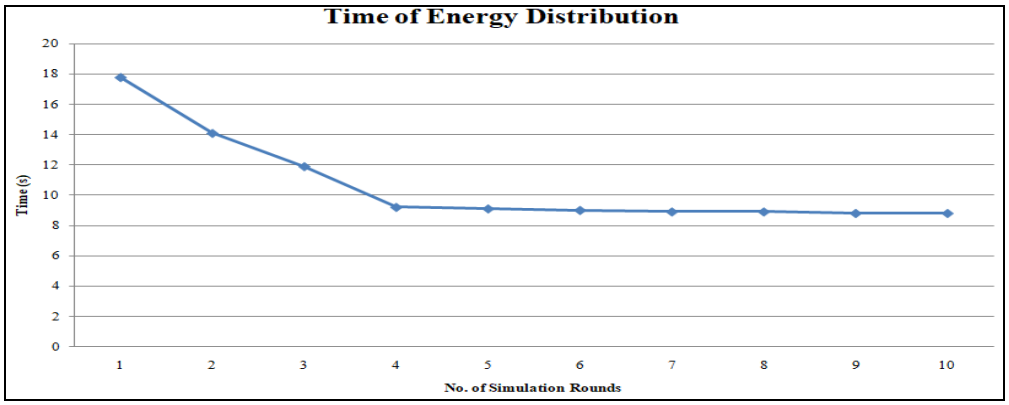

Figure 6: Energy distribution time of the proposed system

The energy distribution time of the designed block chain technology based solar energy management and trading system is shown in figure 6 with table 3. In the figure, x-axis defines the number of simulation rounds and Y-axis defines energy distribution time values measured for the proposed method. The blue line represents the energy distribution time value measured of proposed work and from the above graph; it is clear that the energy distribution time value measured for the proposed model is better and fast.

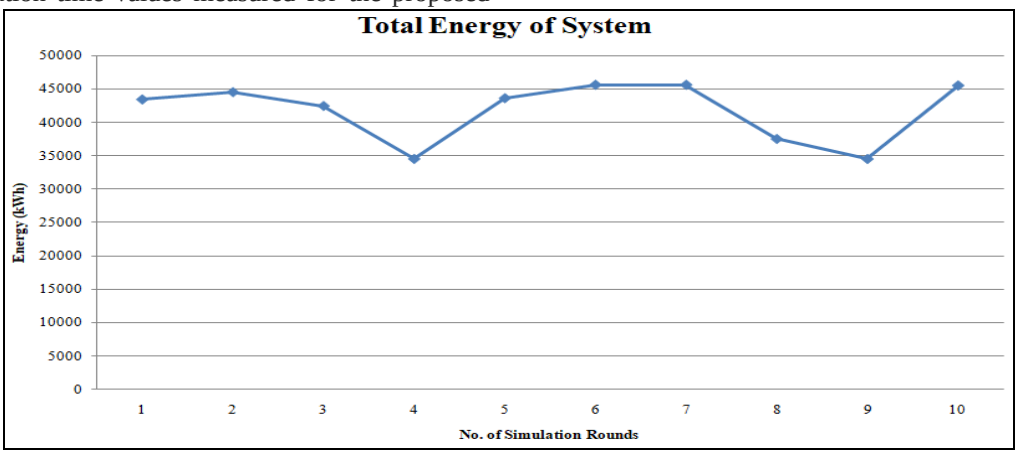

Figure 7: Energy of the proposed system

The energy of the designed block chain technology based solar energy management and trading system is shown in figure 7 with table 3. In the figure, x-axis defines the number of simulation rounds and Y-axis defines energy distribution time values measured for the proposed method. The blue line represents the energy value measured of proposed work and from the above graph, it is clear that the energy value measured for the proposed model is higher but the detection of fraud user also occurs.

V. CONCLUSION AND FUTURE WORK

In this paper, block chain technology based solar energy management and trading is proposed to manage the generated solar energy using PV array.

Solar energy management during its distribution and conservation phases is one of the major issues characterizing in this innovative world and that claims for the design of novel energy management solutions. Achieving high efficiency in the energy management system is crucial to electronic devices. We have analyzed our proposed model for solar energy management and trading is a better option to prevent the management system where solar energy is generated in a large amount using the PV array. Illustrative results point toward the proposed solar energy management and trading system effectively improves the system performance in terms of QoS parameters. Based on the observations of results, we can conclude that the energy distribution time of the proposed system is fast and also work for a high amount of energy. In future work, Solar energy management and trading could be combined with the concept of machine learning as a classifier to train a model based on hybridization with optimization algorithms which may be applicable for fast fraud detection in model with their fraud data. Researchers can use artificial intelligence technique as machine learning approach along with optimization technique for detection and prevention from theft users during the peer to peer energy transmission. When the record is analyzed using an artificial intelligence technique, the theft user can be accurately detected so that more appropriate performance can be achieved in the future.

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