VFAST Transactions on Software Engineering
http://vfast.org/journals/index.php/VTSE@ 2022, ISSN(e): 2309-3978, ISSN(p): 2411-6246
Volume 10, Number 4, October-December 2022 *pp: 131-144*

Energy Trading in P2P Network by using Blockchain in Smart Grid

Afshaar Ahmed[1], Agha Yasir Ali [2], Mishaal Ahmed[3] , Abdul Lateef Khan [4], Manzar Ahmed[5] and Uzma Amin[6]

[1]Department of Software Enginering, University of South Asia,Lahore, Pakistan
[2]Department of Electronic Engineering, Sir Syed University of Engineering & Technology, Karachi, Pakistan
[3]Department of Software Enginering, University of Engineering & Technology, Lahore,Pakistan
[4]Department of Elctronic Engineering, University of Engineering & Technology, Karachi, Pakistan
[5]Department of Electrical Enginering, Sir Syed University of Engineering & Technology, Karachi-pakistan
[6]School of Electrical Engineering, Computing, and Mathematical Sciences, Curtin University, Australia
*Corresponding author email: mishaal100@yahoo.com

ABSTRACT
In recent years, the dramatic increase in demand of electricity utilization has introduced various environmental and sustainability concerns for Conventional Energy Grid based on fossil fuels, which driving the global energy manufacturers to adapt new efficient and resilient energy systems. The conventaional Grid is based on centralized system suffer from power losss, theft cases and cannot adopt new power systems properly. Presently the focus of the scientist and researchers is on the Clean Energy resources and Smart Grid, which has potential to address the contemporary problems found in conventional energy system. On the other side , Smart is a new technology, which allows the integration of clean energy resources such as wind, solar, geothermal, hydro, biomass, and tidal energy systems, ensuring energy availability at all times. The quintessential purpose of renewable technologies is to contrive a sustained community. Nevertheless, it has become a challenging concern for Smart Grid to integrate and coordinate enormous consignment of expanding users and connections. Consequently, blockchain has emerged as a resilient technology in various industries offering data integrity, security, building trust between parties, data immutability, and secure communication. These feature of blockchain making it an auspicious technology for decentralized Smart Grid and Renewable Energy criterion. In this research work, a blockchain based energy trading modal using Peer-to-Peer transactions management is presented. The main goal is to investigate an energy-trading model based on crypto wallets as a digital currency using smart grid and renewable energies. Moreover, contemporary issues of industrial and commercial communities adopting renewable Energy system will be address.

KEYWORDS
Blockchain, Renewable Energy (RE), Smart Grid (SG), P2P Energy Trading, microgrid and distributed system.

JOURNAL INFO
HISTORY: Received: November 17, 2022 Accepted: December 27, 2022 Published: December 31, 2022

INTRODUCTION

In 1870, there were many modern innovations, the demand for energy increased dramatically because of enhanced world economy boosted by industrial revolution 4.0. The primary driver for the revolution was digitization of all the conventional modes of business. The revolution introduced the new philosophies and applications of Nano sensors, IoT, information transparency, robotics, and decentralized systems, which drove the businesses to shift their operations towards a more sustained and environmental friendly value chain. Although these non-renewable sources are able to fulfill the energy demand for many but have significantly influenced the worldwide environment and nature in an adverse way. It has estimated that certain types of non-RE sources such as fossil fuel and coal will dried up by the start of twenty second century with respect to the current global energy consumption rate. The environmental and climate concerns are related with carbon emission. The waste production and resource shortage has derived the industrialists and scholars to investigate alternative forms of energy generation with no CO2. Consequently, the concept of Decentralized Energy System has opened new methods of energy generation such as biofuel, solar, wind, and geothermal energy commonly referred to as RE systems. The concept of RE in Centralized system is not effective enough due to the losses and power control and fail to satisfy the demand of energy. In developing nations the energy demand is dramatically growing due to new devices of IoT are connecting with systems . In addition, one-way flow of energy in CESs eliminated the mechanism of recent emerging users of energy referred to as prosumers.

Moreover, combination of Blockchain and SGs allows the energy consumers and producers to efficiently manage by multiple sources of energy production are it renewable or non-renewable in a decentralized manner. The difference between the architecture of Centralized Energy Systems and Decentralized Energy System is shown in Fig.1.

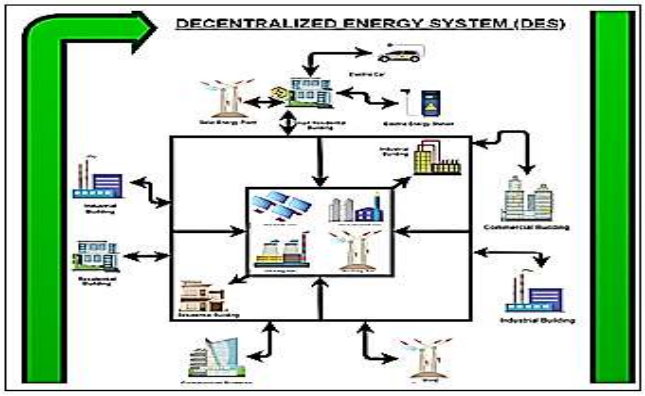

Fig: 1. Decentralized energy system

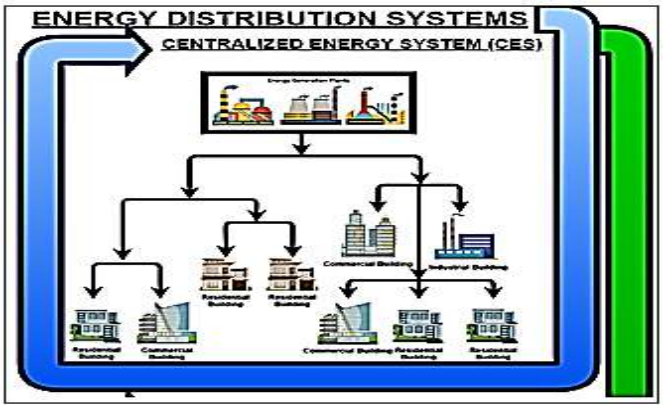

Fig.1. (b) Energy Distribution Systems Architecture

In the above figure 1 (a) (b), the general CES architecture, can be analyze, which is based on one-way flow of energy. The energy starts flowing from the energy generation plants and then dispatched through one-way transmission network to the consumers. It can also be seen that in this type of architecture there is no concept of prosumers. Even if a consumer becomes prosumers in this scenario, the bill calculations will not be free from ambiguities. Moreover, the consumer will have to use some other technology at his residence like Smart Meter, to become a prosumer.

From the Fig.1 it can be clearly analyze that smart house is able to supply and consumer energy at a same time. Moreover, it can also analyze that there are one-way transmission lines; however, these lines can be converted into two-way transmission if the consumers want to become a prosumer. Similarly, it is also significant to understand the energy flow of CESs and DESs in order to gain a good understanding of these systems. It has been already observe that the architecture of CESs and DESs in Fig. 1, present the flow pattern of the energy in both these systems. The difference between the flow patterns of conventional energy and RE are shown in Fig.2 (a) (b).

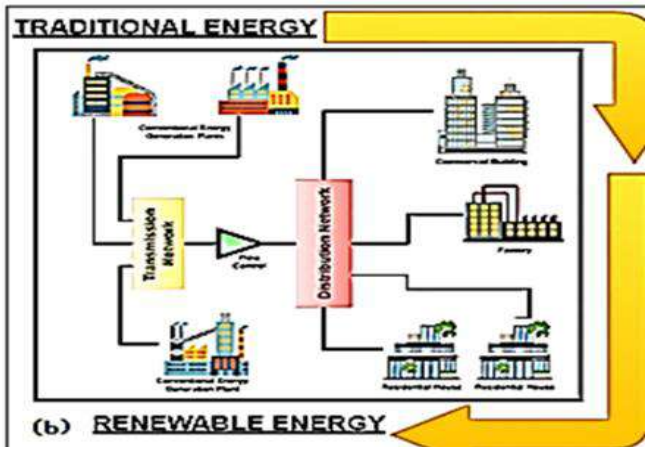

Fig: 2. (a) Traditional energy system

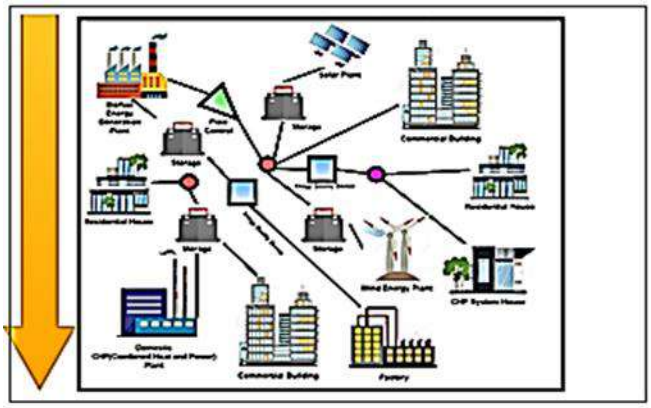

Fig.2. (b) Comparison of Traditional Energy and RE Flow

The blue color boxes in the Fig.2 (a) (b) are the quality services employed to supply RE to the consumers.The global energy consumption report of 2019 highlighted the dramatic shift of energy systems from CESs to DESs using RESs, which revealed that the liberalization of these systems in developed nation's energy infrastructure has been successfully employed and it is slowly shifting the energy demand from conventional to renewable sources to advance towards a sustainable future. However, in developing nations like Bangladesh, Sri Lanka, Kenya, Iran and Pakistan, the situation of energy is quite vulnerable because of the poor infrastructure of power system and declining economy. The energy sector in these countries prohibits the government to shift from CESs to DESs and due to this conditions energy related issues are increasing dramatically. The use of DESs with RESs by the energy market is not able to provide solutions in real time for the users for effective energy management. The concept of blockchain was emerged in 2009; it was assumed that this technique will resolved the problems of trust and transparency concerns in modern businesses. Since 2017, the utilization of blockchain in RESs has become a significant topic for scholars all over the globe from past four years. The sole purpose of DESs and RESs is to develop a sustained global community, which is free from environmental and biological hazards, as well as addresses the energy issues found in previous CESs.

As shown in Fig.3 (a), the utilization of blockchain technology along with RESs and DESs is a perfect match to address the contemporary energy issues [12]. It can empower the decentralization of energy applications like smart girds at its core. Blockchain offers features like decentralized and instant contractual and monetary transactions over P2P public and private networks by satisfying the cyber security concerns [16].

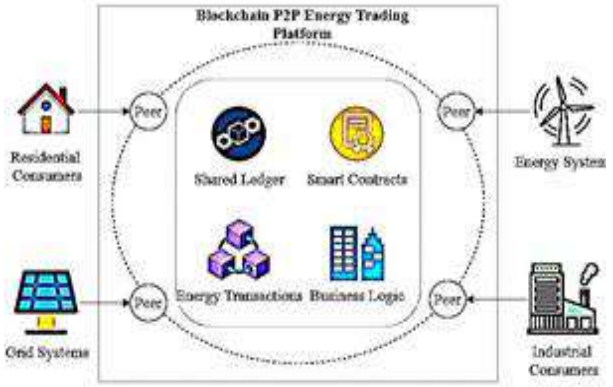

Fig: 3 (a). Features of Blockchain

Additionally, blockchain is sometimes referred to as distributed database. The application of blockchain in the energy sector can be employed in various ways such as REC (RE Certificates), Clean Energy Trading, P2P Energy Trading, Smart Metering, Financial Applications of Energy Efficiency, and Electric Vehicle Charging Applications [42]. This research article presents a P2P based blockchain empowered energy trade platform. The second section of the article discusses the previous scholarly work published in the field of RESs and blockchain technology. The third section presents the material and methods used for this research. Finally, the fourth section ends with recommendations and conclusions proposed future sustainability. In future, these technologies will give more power to energy consumers to produce, monitor, and control their energy requirements. The security of IoT system and proposed blockchain system will resolve the security issues related to IoT as shown in figure 3(b) but one major issue is that if internet block and bitcoin is related with blockchain, system will be collapse globally.

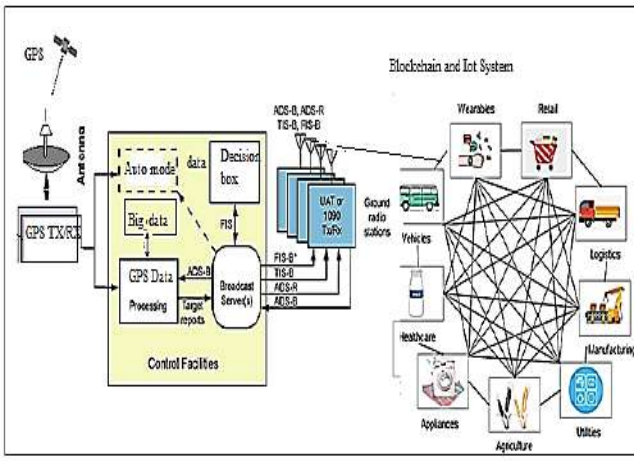

Fig: 3(b). Interworking of Blockchain, IoT and sensors [12]

LITERTURE REVIEW

In the the study the author highlight the modern innovations, the demand for energy is increasing dramatically because of enhanced world economy boosted by industrial revolution 4.0 in 1870, which significantly increased the growing number of modern businesses and technological applications along with the advancement in global society [1]. In this study the author highlight the issues about the traditional grid such as it use the conventional energy resources and these grids rely on one-way flow of energy, information and on fault condition the system suffer from blackout. Also, the energy produced by CESs based on conventional energy sources are non-renewable sources such as fossil fuels, gas and coal and produce pollution[3]. An SG is an energy network, which allows two-way flow of energy and information transection using digital communication technologies, In the study the author describe the way how SG allows the user to detect, react, and pro-act to changes in utilization and multiple issues. In addition, SG allows the consumers to become active participant and use the feature of self-healing [4]. In the study the authors describe traditional grid based on centralized hierarchy, and mention that this grid unable to provide energy effectively to large-scale communities [5]. In this paper the author present the architecture of global energy market and trends such as it is shifting toward to decentralized system and highights critical task for industrialists and scholars to efficiently design the energy systems in an effective manner [8]. The study describe that most of the energy sectors have employed merit-order policies to recognize the energy costs on regional or national level but not local or micro level, which has raised security and transparency concerns for the global community [6]. It is documented that the Blockchain is an emerging technology, which offers promising features like transparency, secure communication, trust between the parties, and data immutability by utilizing blocks of information stored using a chronological approach [9]. The study describe how DESs system minimizes losses and reduces the carbon footprint due to fewer distances between energy supply and demand sites and availability of RE resources [11]. In this paper the author claim that the majority of DES resources are found in the form of RES, which are intermittent and make it difficult to predict their power output. RESs in combination with DESs introduced uncertainty in balancing of demand and supply of energy due to high amount of discontinuity. For controlling the power and losses in SG grid, the blockchain technology is ideal for trading RE [14]. The study describe the energy prosumers administration model by applying blockchain innovation. The model permitted different energy sources to be associated with different clients and makers. Additionally, the authors have attempted to further develop energy effectiveness by examining the demand of consumption. The proposed exchange model can gather, use, and cycle information all the more effectively [28]. In the study the author highlights the specialized point of view, the creators executed a secluded blockchain-based programming stage for expanding the elements of digital currency trades to the sustainable power Market, including a robot-counsel, which recommends prosumers the top rated schemes for energy trade. The outcomes of the investigation showed a ton of guarantee [27]. In this paper the author

explains about the non-renewable sources are able to fulfill the energy demand for many but have significantly influenced the worldwide environment and nature in an adverse way. It has estimated that certain types of non-RE sources such as fossil fuel and coal will dried up by the start of twenty second century with respect to the current global energy consumption rate [8]. In the study the author discuss the concept of blockchain and its related software application in the business and energy sector [38]. It is documented that from 2017, the utilization of blockchain in RESs has become a significant research topic for scholars in all over the globe. In the study the author introduce the concept of DESs and RESs is to develop a sustained global community, which is free from environmental and biological hazards, as well as addresses the energy issues found in previous CESs [12]. In the study the author highlights the features DESs system, which offer various features such as energy availability, secondary energy sources, and quality of service, which addresses the gaps previously found in CESs [13]. In this paper the author discusses the Blockchain features in energy trading in Microgrid. The authors mainly focus the solar system for energy trading using blockchain [40]. In the study the author cliam that the security of IoT system and proposed blockchain system will resolve the security issues related to IoT but one major issue is that if internet block and bitcoin is related with blockchain, system will be collapse globally [31]. In the study the author discuss the Blockchain Method is a digital ledger of transactions that use duplicate copy for all users, who are in the network at time [11]. In this paper the authors the present the Internet of things (IoT) the IoT smart city experimental model by using various traffic profiles for fifth generation technology. The traffic used in this research for modeling of IoT was different from recommended traffic modeling of a Human-type communication. [41]. In this study the authors highlight the issue of the exponential spread of IoT is the dense number of nodes with the huge amount of data over different networks the collision probability and network congestion arises. The author proposed solution that adaptive aggregation based technique on IoT traffic for smart city networks [42]. In this study the author describe the benefits of blockchain model for energy trading in the smart grid [43]. In this atudy the author addressed the energy availability issue however; some issues such as issues of trust, electricity loss, and transparency remained problematic for consumers and industrialists, especially prosumers. In developing countries, it is still difficult for government to manage the transparency of prosumers [14]. In study the author present method how to effectively utilize RESs in an efficient way, Smart Grid is deployed, which is an emerging technology introduced in 2007 [7]. The author claim that, most of the energy sectors have employed merit-order policies to recognize the energy costs on regional or national level but not local or micro level, which has raised security and transparency concerns for the global community [6]. In this research paper the author present the concept of Clean Energy, which utilized with DESs and RESs. Clean Energy is a type of energy, which is passed through quality checks or services. Moreover, it can be clearly observe that there are no energy nodes in the traditional energy flow while there are nodes for different types of distributions in RE systems. It means the liberalization of the energy sector for trading energy, in most of the developed nations [3]. At present, very less amount of research articles related to blockchain in RE trading have been published and many advance country are indulged in integration of blockchain in energy sector. However, blockchain energy systems are yet rare to be found. In this research work , the various aspects of blockchain in energy sector has been discussed. The use of blockchain technology will allow people to share energy among them. Just like how PayPal allows its [17,18.21]. In this study the author describe the increasing utilization of energy, it is very unlikely for the CESs to fulfill growing energy demands in the near future. The energy produce by CESs was based on non-RE sources such as natural gas, fossil fuel and coal. Though these non-renewable sources have been fulfilling the energy demand throughout decades, however, they have very adverse effect on climate [5,7]. The recent report of NNSFC (National Natural Science Foundation of China) regarding global carbon emission indicated the severity of global climate its increasing risk towards human lives. Similarly, with the development of global total global energy system, the demand of various types of renewable, non-renewable sources and worldwide CO2 emissions increase rapidly since 2019[2,5].

PRSENT STATUS OF BLOCKCHAIN & CLEAN ENERGY

(I) Contemporary Energy Status

The status of global energy poses various types of unprecedented risks and threats to the global society and environment. The energy consumption of various regions over the period of five years is shown in the Fig.4. The energy consumption is shown in Extra joules per annum has been used to portray precise results of each global region. Extra joule is a very large number, which is to one quintillion (10¬18) joules, and it is represented as EJ. It means that the global energy consumption is way beyond a common individual's imagination and playing a significant role in advancing global community towards sustainability.

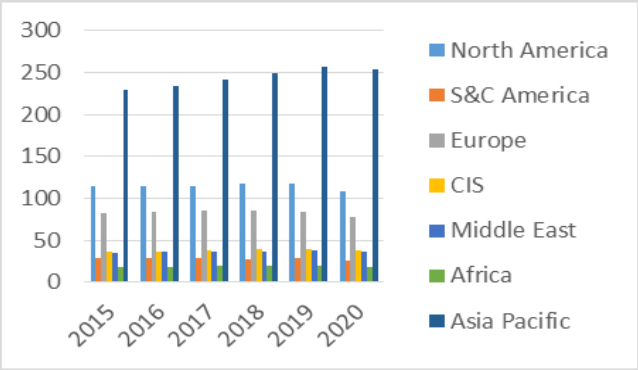

Fig.4. Global Energy Consumption Statistics

The curves are presenting dramatic growth in energy demand. The decline of energy demand in 2020 was very significant since it was the second time that global community faced this dramatic breakdown after World War 2. The primary reason for this drop was the outbreak of COVID-19 pandemic in 2020 and restrictions imposed by governments which led to the downfall of global economy. Nevertheless, in 2021, the restrictions imposed for COVID-19 were proportionally laid off in 2021, which has dramatically increased the global energy demand. The developed countries having DESs and RESs are prospering towards sustainability; however, underdeveloped nations are still struggling to shift their energy architecture towards DESs and RESs. There are social and economic gaps and concerns for developing nations in order to shift towards a new infrastructure. It means that in order to implement DES and RES in effective manner in these countries, new technologies offering security must be employed. Blockchain, in this regard, resolves all the security and trust related issues along with transparency.

(II) Challenges in Contemporary Energy Sector

The contemporary global energy sector has many issues such as power losses, control the power and electricity theft (under developing countries). One big issue is the cost of electricity, which is very high especially in Pakistan establishment taking more than 80% budget and main source are these three consumable items. If these items will be so expense, no industry can grow. Now all industrialist is shifting industry from Pakistan to other countries where all these three items are cheap and definitely, the cost of the product will be low such as in Bangladesh and India. Moreover, the biofuel production is very insignificant for developing nations [2], In future, there is no hope that these items will be at low price because the current energy infrastructure in developing countries are fully dependent upon the third parties which results in various types of disadvantages like energy theft or loss. Such types of thefts or losses can be seen in developing nations like Pakistan. Contemporarily, such problems have become quite common, which in turn, impacts the economy of the nation [6]. Developing nations like India or Bangladesh offer best conditions to attract all industrialists such as cheap electricity, gas and tax conditions and economic is growing rapidly. For instance, India is engaged in building RE with the help of foreign investment and at a very cheap cost [7]. Therefore, various types of industries are shifting to these countries through foreign investments. Countries like Pakistan are required develop their technology in the field of electricity as the current architecture of grid systems is centralized, which in turn, results in economic loss for the government. The blockchain is best technology for Pakistan and after the introduction of SG concept, the power can be control and energy system can be making more secure. Contemporarily, in under developing country, the electricity system mostly is centralized and depend on third party system for electricity demand and supply. After the rapid development is RE system in recent years, such as in solar and wind energy system, the users are installing solar system in home from 2 KW to 120 KW in ruler areas as well as in urban areas due to high price of electrify [11]. Many solar and wind power plants installed in under developing countries like Pakistan from last six years for commercial and domestic proposes. Solar system is more attractive because it depends only on the sun light, which is cheap source of electricity and for night, energy can be stored and can utilized. The wind turbines can install for harvesting the energy near seaside but also it depends on speed of the wind. Many wind turbines are install in Pakistan in 2006. Wind turbines are recommended for near sea, because the speed of the wind is normally high. Due to these conditions wind turbines use is limited and install on commercial basis. On other hand, the solar system depends on sun light these can be used in anywhere in the world. Solar system efficiency is low, and in future, it will be required to increase the efficiency of solar cells. One way is to use Nano technology to increase the efficiency of the solar cell and reduced the size the solar panel. For example, Nano coating, and paint [1]. For the wind, turbines the Nano coating and Nano fiber material, Nano coating and paint can be used in the SGs [2].

(III) Electrical Grid Systems

Advancement in electrical grid technology has been seen in the last decades, which fulfilled the demand of energy, and advanced the global society through various technologies. This section, presents an overview on the conventional and contemporary grid technologies and their problems and eatures.

(a) Traditional Grid Technology

The power industry of a large energy network is to break the imposing business model of the electric force framework change, liberate, present of contest, and advance the change of force framework. The design is to allot assets all the more reasonably, further develop the usage proportion of assets, and advance the organized improvement of force industry, society, economy and climate. MG (Micro Grid) power industry is acquainted to understand the nearby utilization of distributed energy production and diminish the impact of MG on huge energy network. Power Company needs to communicate with numerous other outsiders in

conventional energy market model. Attributable to contrasts among MG and enormous network and their grid markets, power market model of MG utilizing power markets model of huge framework will experience the accompanying issues". The focal association needs to recruit countless staff to keep up with the focal data set, during the time spent clearing the exchange, connecting with banks and other outsider monetary foundations for incessant editing, and the expense is high. As such, after development of the energy market, centralized control system is at this point not reasonable for MG. With the advancement in blockchain innovation, each member in an organization can execute transactions straightforwardly with other organization member without including an outsider go-between. Blockchain innovation can be applied to control exchanging. Moreover, with regards to MG, it can address the issues of the contemporary energy market.

(b) Micro Grid Technology

The microgrid (MG) will play key role in controlling the conventional and non-conventional energies in future power system. The microgrid are capable of trading energy between different entities. The energy system of the microgrid can be such as mini hydro plants, solar cell, wind energy, fuel cell and efficient energy storage system is required to make sure provide energy to users with no delay and all time availability. These all system can ne integrate for providing elcentricity[15]. Many other applications can be added in the SG system such as water storage, filter plants, heat could be used for local process heating or house heating, allowing flexible tradeoff between the needs for heat and electric power [13].

(c) Input sources of electricity

The input sources of energy in Microgrid are different from conventional grid or traditional grid because in conventional system the thermal &hydropower are main source of energy and under normal circumstances, the power supply of LG is stable.

(d) The control strategies

In microgrid the power are combination of conventional, non-conventional powers and transmission network, transmission network and distribution networks. The control center is responsible for controlling power in grid . The control system in conventional grid is to ensure the continuity of power supply and maintaining power supply quality. Now a day, the MG control scheme can be classifying into following stages such as master, slave and peer-to-peer control. The power control technique in MG power control the level, can be divided into distributed power supply, management control of the upper layer and the hierarchical control belongs to master-slave control

(e)Participants in conventional Grid

In the conventional grid the main participants are high power generators, traders, and large industrial users.

(f) Volume of transactions is large

In MG, the major components are generators, residential and industrial user. The purposes is to sale electricity to market users at disparate level.

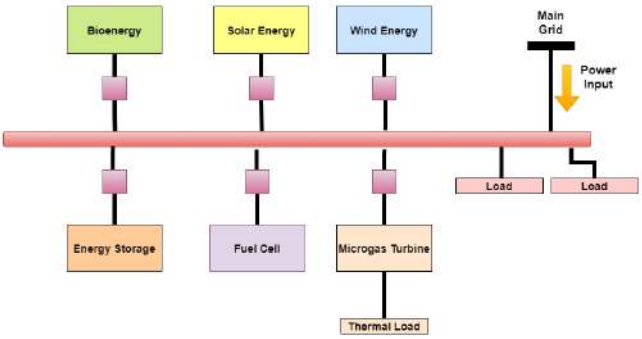

Fig.5. MG System Architecture

The idea of SG depends on Micro Grid (MG), which is an electrical framework that shows various loads and conveyed energy assets, which can work correspondingly with a little autonomous energy framework. It improves unwavering quality and accessibility of energy through dispersed age while expanding productivity with diminished transmission length and easy coordination of elective energy sources. SG is a modernized electrical grid framework (essentially an advanced type of MG) that uses IoT or specialized gadgets to obtain information in regards to practices of buyers and makers in a robotized way to improve the monetary, proficiency, manageability, dispersion, and dependability of energy frameworks by utilizing various types of algorithms based on through wide region checking. The design of SG is displayed in Fig.5. It can be clearly analyze that no central authority is controlling the overall system. It is the responsibility of IoT energy based platform or application to dispatch energy. There are various components of a SG system. We have already discussed about the components of a MG system and its drawbacks. Now we will discuss about the components of SG system. Table 1 portrays the components of a SG system. The smart grid technology control the devices wireless mostly such as staring and shutting off power by mobile deice. AC and DC.

Table 1. Components of SG

Name of Features	**Description**
Resources, Devices, Machine, Electrical Control	• Medium Size and Micro-Turbines • Permanent Magnet and Doubly Fed Induction Generators • Efficient Inverters • Self-Excited Induction Generators • Asynchronous or Synchronous Generators • Induction Machine and Dc Machine Based Storage System Such as Flywheels
Advanced Electrical	• Dynamic Design of Wind Turbines • Bio-Fuel Based Turbines

Design of Devices and Components	• PV Solar Cell System with High Insulation System and Sun Tracking System to Get Maximum Power. • Minimum Looses Smooth Output of Wind Farms
Types of Loads	• Dynamic Modeling of Loads • Adoptive and Frequency/Voltage Dependent • Characteristics of Loads • Real Time Load Shedding Planning • Adoptive Load Management • SCADA Based Control
Energy Management Methods	• Both Systems Adoptable Either Centralized Vs. Decentralized Control System. • Impedance Matching to Control Reactive Power and Minimizing Losses • Efficient Protection Methods • Implementation of Hybrid Sources to Control Fault Current Levels in The Micro-Grid • Smooth Coordination with Other Micro-Grid with The Conventional Grid • Intelligent Interface System • Operate in Both Modes Grid Connected or Islanding and Detection Methodologies • Low-Voltage Controlling System • Incorporates Micro Grids
Interaction and Communication	• Two Way Energy and Data Transmission • Utilize IoT Devices for Analytics • Self-Healing • Effective Interaction • Enable Consumers to become Prosumers • Transparency in Energy Source • Automatic Maintenance

The power availability.Looking at the features SG systems, it can be concluded that all the problems previously found in Micro Grids or CESs are being addressed by SG system. Hence, it is significant to use blockchain with such an efficient technology.

(V) **Scholarly Contributions in Blockchain and SG Technologies**

Since 2017, there has been a dramatic increase in the scholarly literature of blockchain applications. In the context of energy sector and blockchain, there is diverse amount of literature available published. However, the literature on SG and Blockchain is still remains insignificant. In this paper, we collected about 34 articles related to energy trade in grid system and after filtering them only 11 articles were captured to be precise and aligned with the context of this research article and other were discarded. The articles range from 2017-2021.

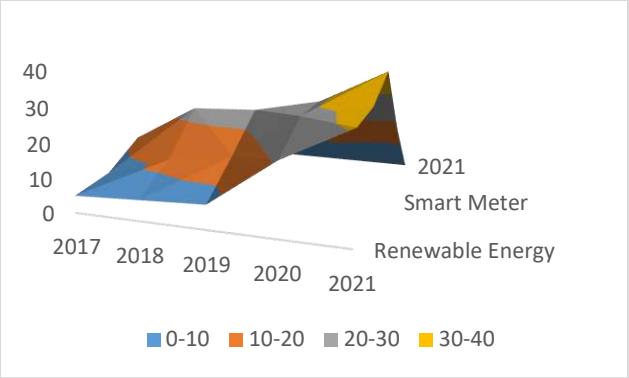

Fig.6. SG System Architecture

The figure 6. Shows Smartgrid system architecture. In 2017, a publication on green blockchain investigated the utilization of blockchain executed on PREDIX, an industrial OS. The investigation introduced the scenarios of green transactions exhibited inside an eco-locale [26]. Likewise, another examination introduced a cryptographic money based energy exchanging stage and investigated that how a blockchain based framework coordinating brilliant agreement usefulness can be utilized to share energy to advance saver matrices for the administration of power in the Italy Region. Another explorative study presented energy prosumer administration model by applying blockchain innovation. In 2018, different studies proposed new ways to deal with resolve issues found in execution of blockchain in environmentally friendly power area. For instance, an investigation introduced an extensive idea, market plan and reenactment of a neighborhood energy market between one hundred houses. The proposed approach depended on an appropriated data and correspondence innovation, for example a private blockchain, which underlines the decentralized idea of nearby energy markets. The proposed framework furnished energy prosumers and purchasers with a decentralized market stage for exchanging neighborhood energy age without the need of a focal go-between. The authors further introduced a starter financial assessment of the market component and an exploration plan for the mechanical assessment of blockchain innovation as the nearby energy market's primary data and correspondence innovation [29]. Likewise, in one more exploration introduced in 2018 a few researchers introduced the idea of Electricity Consumption and Supply Management System (ECSM) with utilization of blockchain innovation. ECSM gave the usefulness to screen and record consistent data about inbound and outbound energy to/from power matrix. However, checking inbound and outbound energy, the arrangement give the likelihood to oversee in programmed and manual manner when energy ought to shipped off energy matrix. The exploration further uncovered that data about inbound/outbound energy is a piece of brilliant agreement, which is confirm and put it away in each hub with the assistance of disseminated record [30]. Likewise, another examination investigated the subject of blockchain, environmentally friendly power credits, and carbon credits.

The investigation prescribed that to work with the far-reaching reception of clean energy; we should devise functional monetary motivators to send clean energy resources while decreasing boundaries to get to that spotless energy. While sustainable power credits and carbon-offset credits effectively push these objectives forward, the related bookkeeping and the integrated frameworks actually experience the ill effects of various defects that drive costs up and slows the adaptation of clean energy resources. The article additionally examined about blockchain innovation as a promising answer for secure and straightforward exchanges through which credits can be handily followed from age through possession exchanges to extreme recovery, leaving a basic review trail, fundamentally decreasing the related time and cost, and empowers makers to adapt their credits following age. In addition, the creator likewise examined about Clean Energy Blockchain Network (CEBN), which has as of late reported an organization with the Silicon Valley power, where we will apply blockchain innovation to work on their support in the low carbon fuel standard (LCFS) program. This certifiable organization shows that how blockchain innovation can significantly work on incredibly complex exchanging conditions and empowers the useful execution of important projects, for example, LCFS that monetarily boost clean energy creation and use [31]. Another examination introduced a stage for blockchain energy exchanging for Smart Homes. It is difficult to fashion information called exchange produced by utilizing blockchain. With this unforgivable exchanges, home digger that halfway cycles every one of the exchanges produced in server home know data about energy. In light of this data, the creators suggested that sustainable power exchanging stage utilizing Ethereum's shrewd agreement to guarantee secure energy exchanging run naturally without the outsider mediation in a MG [32]. In 2020, an examination investigated blockchain innovation to manage ordinary energy issues as disseminated information stockpiling innovation. A twofold layer structure of energy exchanges dependent on blockchain in multi-MGs was proposed by the creators to give decentralized exchanging, data straightforwardness and common trust arrangement of every hub in the exchanging market. In the introduced model, the focal hub inside the MG gathers the interest data of the exchanging market lower layer and sends them to the exchanging business sector of multi-MGs in higher layer to look for the energy exchange. Besides, the ceaseless twofold closeout component is utilized in the exchanging business sector to ensure free and reasonable exchanges among hubs. The proposed exchange system viably diminished the exchange volume with the primary matrix, which further develops energy usage. Far reaching recreation results demonstrated the possibility of the proposed exchange structure [33]. Similarly, another article investigated the promising components of blockchain in energy area. The paper efficiently checked on the hypothesis of blockchain and investigated the flow status of energy blockchain exploration and applications utilizing a visual bibliometric examination technique and the Scopus data set from 2014 to 2020. The outcomes show that the quantity of distributions about blockchain innovation in the energy area have been soaring, particularly since 2018, which demonstrates the joining blockchain innovation with energy area is another cross-cutting exploration region with expanding consideration. The article moreover uncovered that at the public level, agricultural nations start to move to the world stage, getting up to speed or in any event, unbelievable a few customary created nations in the field of energy blockchain. The group investigation consequences of the examination show that the current energy blockchain research centers around sustainable power, attempting to tackle the bottlenecks in its advancement cycle, and giving better answers for the substitution of fossil energy by environmentally friendly power. The creators at last battle that blockchain might be filling the environmentally friendly power and controlling our energy maintainability [34]. In 2021, an investigation addressed a blockchain-based environmentally friendly power MG plan issue, where the bank funds an advance to the force organization to set up sustainable age units and the force organization likewise offers a credit period for producers to animate interest. Blockchain innovation can be applied to moderate default hazard. The target of the article was to decide the number and area of sustainable age units, energy cost in the hour of-utilization plot, credit time to producers, and blockchain execution exertion while boosting the normal organization benefit. An answer strategy dependent on hearty sort 2 fluffy writing computer programs was created to take care of the portrayed issue. The utilization of the proposed approach was inspected utilizing an experimental contextual analysis. The outcomes show that dubious interest and default hazard strongly affect the arrangement, and the complete benefit of the sustainable power MG is worked on by around 1.73% utilizing the proposed approach [35]. Likewise, one more investigation planned to decide the most reasonable sustainable power choices that can be utilized in blockchain ventures. In this unique situation, right off the bat, a wide writing survey was made and six distinct rules that could affect this not really settled. The investigation cycle of the comprised of two distinct stages. Right off the bat, the importance levels of these measures were determined with the assistance of stretch kind 2 (IT2F) dynamic preliminary and assessment research center (DEMATEL) - logical order measure (ANP) (DANP) technique. As per the examination results acquired, it not really set in stone that coherence in energy supply and legitimate conditions are the main measures. The creators suggested that while picking among environmentally friendly power options, it is important to focus on the lawful guidelines in the country. Another significant point is that consideration sought to pay to this issue in environmentally friendly power sources to be chose to have practical advantage from energy in blockchain advancements [36]. Again, in the second period of the

investigation cycle of the examination, five distinct sustainable power choices recorded by their reasonableness in blockchain innovation. In this interaction, the IT2 fluffy methodology has been thought about. Thus, the creators inferred that breeze and sun powered energy are the most appropriate energy options for this innovation. Considering the outcomes got, it is perceived that nations that utilization blockchain innovation should give specific consideration to wind and sunlight based ventures. In such manner, organizations that utilization wind and sunlight based energy with people or establishments utilizing blockchain innovation ought to be in collaboration.

VI. Blockchain Technology

Blockchain Method is a digital ledger of transactions that use duplicate copy for all users, who are in the network at time . A ledged is considered as the entire backbone of the blockchain application or system. The properties of the Distributed Ledger Technology are that they Programmable, Distributed, Secure, Immutable, Anonymous, Unanimous, and work in Timely manner use stamp [1].

(a) Challenges of Traditional Energy Infrastructure

In this research, we have presented various contemporary challenges of blockchain in energy sector and addressed them by proving solutions. The current challenges are such as Variability and Uncertainty,balancing demand and supply ,Prediction, Forecasting and scheduling, cost, handling storage at end userand losses.

(b) Role of blockchain in Energy Sector

The Blockchain technology playing key role in the energy sector and many scientist has recommending the blockchain for the energy sector [1]. In Fig.7, the current market of blockchain technology with respect to annual energy consumption has been highlighted [2]. TWh stands for Terra Watt per Hour. Blockchain technology reduce the corresponding costs while keeping record of communication and all users in network can identify record [10]. With the introduction of Nanogrids, the blockchain technology on the communication will be among the energy devices (heaters, vehicles, batteries, solar PV installations, etc.) and with the grid operator (SGs) [12].

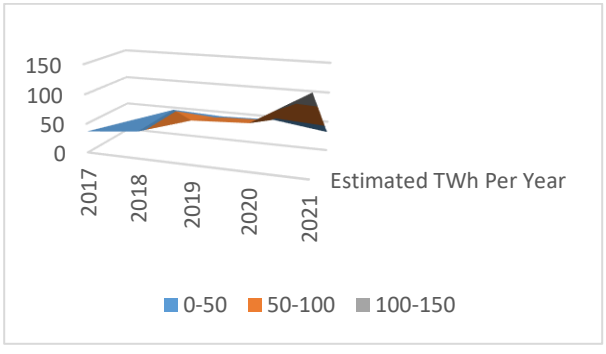

Fig.7. Bitcoin Energy Consumption Worldwide

In future, these technologies will give more power to energy consumers to produce, monitor, and control their energy requirements.

(c) Blockchain in Digitalization and Energy

Aapplications for blockchain can identified in the emerging fields of IoT platforms and the development of ICT such as in smart homes Blockchain facilitate digital P2P transactions; therefore, can potentially enable machine-to-machine (M2M) communication and data exchanges between smart devices. An increasing number of smart devices (20.8 billion) could connect on the Internet by 2020 [4]. In the energy space, smart meters and ICT equipment are increasing and adopted in power systems [5]. The number of smart meter readings alone is expected to rise from million a year to 220 million per day for a large utility company [7]. This trend combined with the power of automation and big data analytics can potentially transform the value chain in the energy sector [19]. The green certificates are discussed in Blockchain in local energy markets it can give incentivize and end-consumer participation [8].

VII. Materials and Methods

At present, very less amount of research articles related to blockchain in RE trading have been published and many advance country are indulged in integration of blockchain in energy sector . However, blockchain energy systems are yet rare to be found. In this research work , the various aspects of blockchain in energy sector has been discussed. The use of blockchain technology will allow people to share energy among them. Just like how PayPal allows its [17]. Now the industries are moving towards renewable energy and clean such as companies such as Exxon, BP, and Shell have announced plans to invest in such huge projects.

BLOCKCHAIN BASED ENERGY SYSTEM ARCHITECTURE

The application of blockchain provides four key features as shown below:

(a) Information Interaction

The communication and the information based on the controller and the device on which the blockchain energy application to be installed. The device and the controller goes through five layers of abstraction in a concurrent manner. The first layer identifies the device information and validity. In the second layer, data is collected and verified then transmitted to the control monitoring layer that passes the information to the scheduling and coordination layer for real time interaction.

(b). Multi Energy Trade

The feature of multi energy trade is very significant for modern society. It offers direct transactions via digital currency using the internet. Moreover, it also offers the feature of online price transparency, which enables the users to select from the most suitable energy option available for their utilization.

(c) Privacy Protection

The information shared or stored in blockchain is very secure. The feature of privacy protection enable through cryptographic algorithms. For instance, Bitcoin uses SHS256 cryptographic algorithm for data protection. Moreover, privacy protection also offers ease of access control and key management as well.

(d) Operational Control

Another significant feature of blockchain in energy is effective operational control. It provides high fault tolerance, which ensures data immutability. It also provides peer consistency along with self-healing mechanisms. Furthermore, blockchain exhibits a distributed structure, which aligns with the contemporary DESs such as SG. Conventional power system was popular and it based on centralized power grids, but these days this system has are inefficient and massive energy losses [15]. Now SG will used blockchain technology, which is distributed and more secure. the working of the blockchain technology is given in figure 8, If any user wants to sell Extra Generated Energy, can sell directly to buyer but copy of the transaction will be send to all user in the network. Hence, it is more clear and efficient method.

(e) Block Structure

The typical block of blockchain network based on P2P energy architecture is shown in Fig.9.

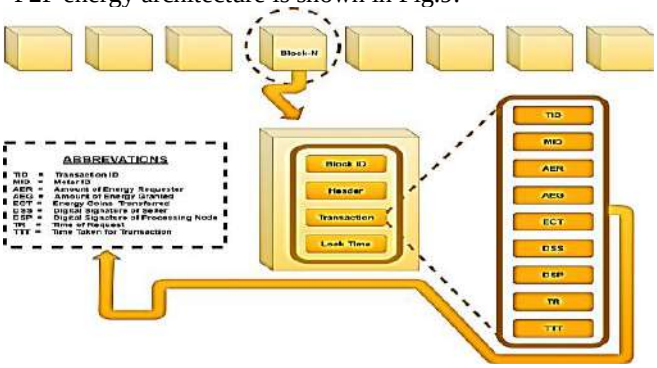

Fig.8. Block Architecture

In blockchain system predefined processing and consensus nodes are used for making block called hash consists of Block ID for differentiate the users, using Header, a Secure Hash Algorithm (SHA) in which there is Lock Time, which indicate the time of addition blocks or frame for transmission. All transaction started when the buyer requests for energy from the other users via of the supervisory nodes. There are number of technologies used to implement the system. These technologies are discussed below:

(a) Energy Storage and Management in MG

There are following Reasons for Energy Storage:

a) Fulfilling the Demand Response
b) To generate more incentives
c) For electric vehicles
d) To avoid fluctuation
e) To control eenvironmental impacts due fossil-based fuel use.
f) Use of advance battery to provide more power in blackout case.

(b) Deversity impact of RE System In MG

There are many advantages of integrating energies in Distributed generation system such as

(i) support weak grids,
(ii) Add grid voltage
(ii) Improve power quality

In case of low power factor for reducing losses the capacitor banks can be used to control and manage the power flows to make the active and reactive power balance. In Figure 18, the proposed method of integration of energy in gird is shown above. If energy harvested and take care of control system, it can reduce environmental impacts such as:

(i) Reduced emission of hazardous gases
(ii) Reduced dependencies on local or imported fuels

VIII. PROPOSED MODE OF OPERATION FOR MG

In proposed model each home would have its own uninterruptible power system and the system has the capability to work both modes such grid-connected mode and stand-alone mode. It is supposed that the system is capable of producing a smooth, uninterrupted transition between these modes by using an advanced islanding detection resynchronization algorithm as shown in Figure 10. In microgrid the control of voltage and frequency is important factor because grid operator must know the issue and how to solve the issue quickly in seconds of time related to frequency and voltage fluctuations in transmission line system [22]. This variation occurs very rapidly and must be control in timely manner.

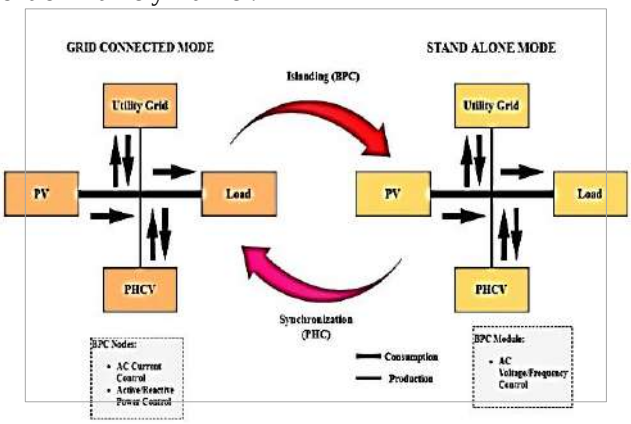

Fig.9. Modes of Operation in MG

These variations can control by using device Automatic generation control (AGC) signals to grid generators. Emergency generator used in the reserve to control the fault when occur the reserves generators are used when main generator on the system become faulty as shown in figure 9.

(a) Digital Currencies

The innovation in blockchain has brought about various digital currencies such as Ethereum, Bit Coin,

Lithium, and Cohort. In a blockchain application, all energy recourses can be controlling Calculation (SHA); Lock Time, which shows the hour of expansion of that specific square into the organization; and the exchanges. Every exchange is created when the purchaser demands energy from the exchange workers of the administrative hubs. The exchange some portion of the square construction comprises of information explicit to every exchange like

a. Transaction ID (TID),
b. Meter ID (MID),
c. Measure of Energy Mentioned (AER)
d. Measure of Energy Allowed (AEG) for the mentioning purchaser by the administrative hubs dependent on the accessible energy from the dealers
e. Energy coins Moved (ET) by the purchaser for the exchange Computerized Mark of the Vender (DSS) showing a fruitful exchange and Advanced Mark of the Handling hub (DSP) demonstrating approval of the exchange
f. It likewise incorporates timestamps showing Season of Solicitation (TR) and Time taken for Exchange (TT).

***(b).*Power Management and Communications System**

With the introduction of blockchain technology, all energy recourses can be control such as renewable resources and control changes in grid operating conditions. It can provide additional benefits because it is distributed generation system. Key components are Smart meter, dispersed generation (DG) [6], Information technologies, Energy management systems, advanced control and protection systems,

(c) Credit Based Transactions

There are some issue related to the approval and expansion of exchanges in the system, when the defers information arrived of virtual money for the particular client, clients may confront a lack of virtual cash briefly. A credit-based exchange framework helps such clients in buying the necessary energy without real ownership of virtual monetary forms at that point. Li et al. [38] used a credit-based installment plot where every hub is designated a character, a bunch of public and private keys, a declaration for one of a kind recognizable proof, and a bunch of wallet addresses upon an authentic enrollment onto the blockchain. Upon instatement, the wallet honesty is checked and its credit information are downloaded from the memory pool of the administrative hubs (which store records using a loan based installments). The solicitation from every hub for the arrival of credit-based tokens is approved by the credit bank oversaw by the administrative hubs and delivered if the mentioning hub meets the predetermined standards. These tokens can be utilized to purchase electricity from hubs [37].

(d) Smart Contracts and Mathematical Models

In order to utilize the blockchain technology for energy sector, the following the equations (related to power consumptions) must be kept in consideration by the developers while building the blockchain application:

$$P_t \geqslant h_r \times E_m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$P_{tc} \geqslant h_r \times E_{min} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

$$M_{rew} + T_{m.fee} = M_r \geq Etc \times E_{Pmin} \ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

A few easy manipulations yield the desired upper bound:

$$P_t \leq B_r \times C_p + T_{m.f.} B_t \times E_{Pmin} \ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

$$P_t \leqslant B_r \times C_p + T_{m.fee} \times B_t \times E_{P.min} \ldots\ldots\ldots \text{(v)}$$

P_t = total power consume
h_r = total hash rate
E_m = min energy per hash
M_{rew} = Mining rewards
$T_{m.fee}$ = transaction fees
$M_{t.rev}$ = tot. Mining revenue
E_{tc} = tot. Energy consumption
E_{Pmin} = min. electricity price.
B_r = block reward
C_p = coin price
B_t = Block time

Above equations cab be used to calculate the total consume power and other parameters. In order to devise a blockchain application for energy sector, build smart contract is necessary as well. Here we have discussed the working of a blockchain energy based smart contract. This can support blockchain developers around the world to assist them in their development of smart contracts in energy sector. Fig.14 portrays the flow of blockchain based energy smart contract [17].

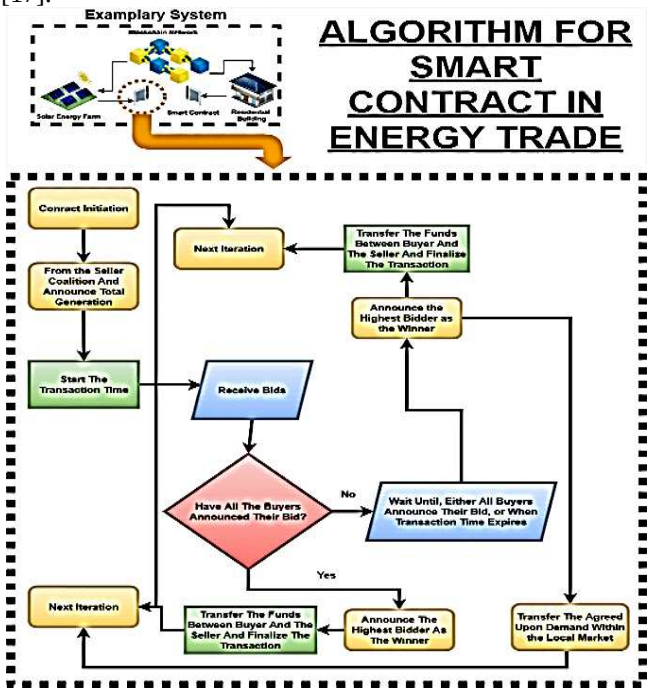

Fig.10. Energy Contract in Blockchain

In figure 10, the flow chart of the energy trading system is given. The following Simulink model is used in this research work shown in figure 20. In MGs, all solar

energy used and stored in grid. For simulation, the total power is 100 KW to 255 KW for PV Load efficiency 30% to 100%. Selected for area. The total load distributed among the 16 load points were considered. The list details of the components given below;

IX. LOAD PROFILE SIMULATION

Unbalanced dynamics protection/restoration strategies used for in proposed model.

(a) input resources

- PV cell, e-cars, batteries, fuel cells, wind, etc.
- VPP
- Decentralized System

(b) Components

- Smart Metering – meter reading + active meter controlling
- Smart Power control
- Low cost system

The proposed energy system for blockchain is portrayed in the given fig.10. We can clearly see that using renewable sources is additionally providing big data analytics. In order to analyze the working of blockchain along with MG. Therefore, it is significant to understand the working of a MG system with blockchain shown in Fig.11. The flow chart explains the proposed system of Simulink model. The figure 13 shows the energy trading in the present of storage system and benefits. We have analyzed two load points in order to compare the results.

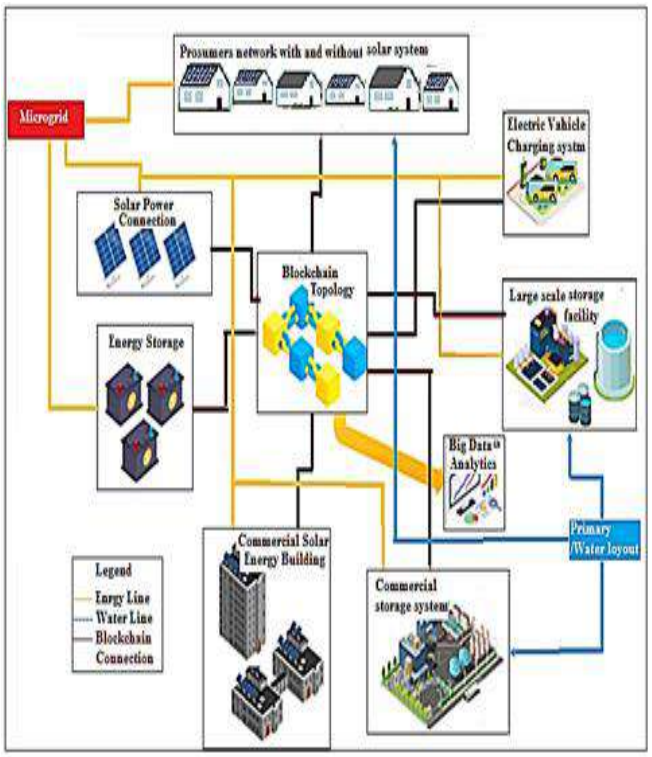

Fig.11. Blockchain in SG & RE

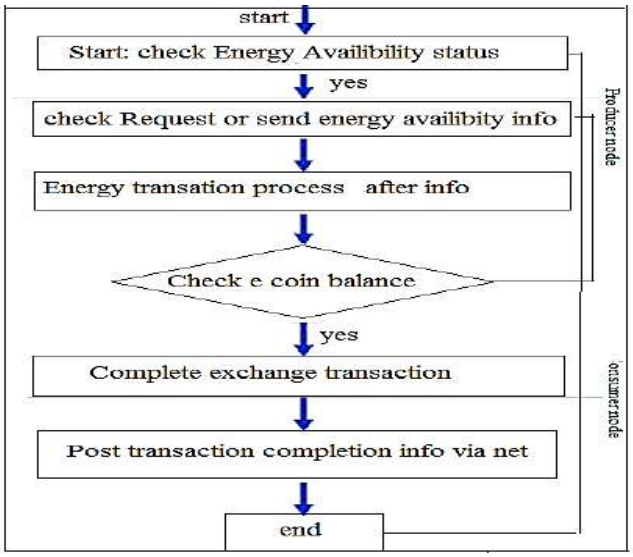

Fig 12 Flow chart model trading

Figure 12 shows the flowchart working of blockchain with smart Grid and input resources renewable energy systems.

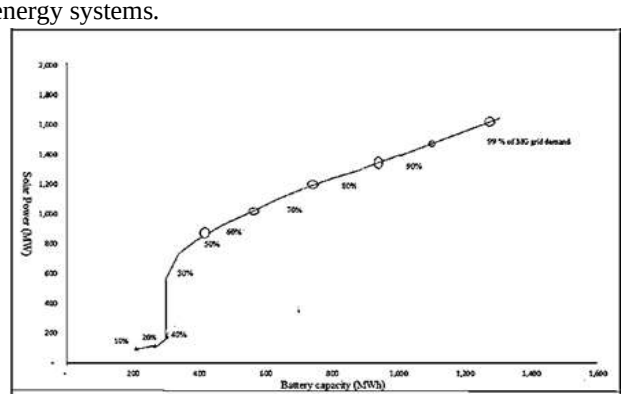

Fig.13 energy trading and storage system

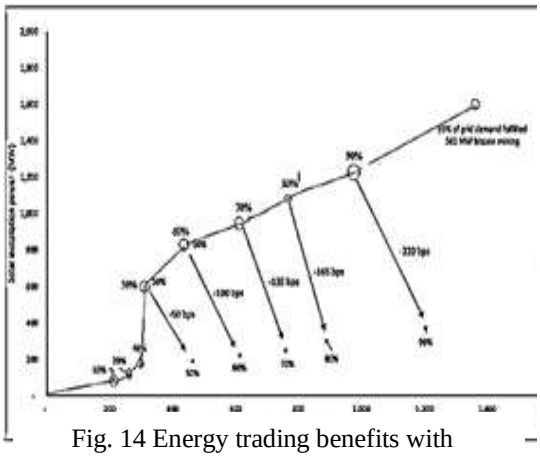

Fig. 14 Energy trading benefits with

From figure 13 and 14, it can be analyzed, when Load increase, the output power of the PV cells increases and PV system operate at MMP point. It can be seen at 40% load efficiency to 90% it covered maximum load points further if the efficiency increased to 100% with the storage system in MG, the more benefits can be generated.

CONCLUSION

In this paper, the blockchain technique for energy trading with high efficiency and secure transaction was investigated. There are several benefits that can be taken by the deployment of this blockchain technology such as decentralization feature shared by blockchain technology, transparency, secure transaction, minimizing electricity theft cases and earning more profit. Adding the large energy storage system in SG there are many benefits as such as no blackout and reliability of the system increased as shown in this paper. For simulation, sixteen load points with storage system selected supported by SG. From the results and calculation it can be concluded that by maximizing the load connection in the network, with the efficient storage system more profit can be generated by using blockchain technology and losses can be reduced. the smart grid can control new input resources properly without losing control , such as solar and wind energy system.

ACKNOWLEDGMENT

First, I thanks to Allah for his countless blessings, second, I would like to deeply thank my mentor and advisor from the core of my heart for guiding me throughout my academic career. I also thankful to all the teachers for their advice, guidance and continuous support throughout my academic and research career. Finally, I would like to thanks to all my parents for their spiritual guidance, support, and encouragement-loving attitude.

CREDIT AUTHOR STATEMENT

Afshaar Ahmed: Methodology, Visualization **Agha Yasir**: Data curation, Writing- Original draft preparation. **Mishaal Ahmed**: Visualization, Investigation. **Abdul Lateef*:*** *Conceptualization,* Software, **Manzar Ahmed**: Methodology, Validation, Data curation **Uzma Amin:** Writing- Reviewing and Editing

COMPLIANCE WITH ETHICAL STANDARDS

It is declare that all authors don't have any conflict of interest. Furthermore, informed consent was obtained from all individual participants included in the study.

Note: this paper was presented in Authorea as preprint for public views link:
https://www.authorea.com/users/474221/articles/564174-blockchain-based-renewable-energy-p2p-trading-in-smart-grid

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