Application of Advance Energy Storage System in IoT and Blockchain

Fahad Ahmad Siddiqui[1], Afshaar Ahmed[2], Lubna Farhi[1], Mishaal Ahmed[3], Manzar Ahmed[5], Uzma Amin[4]

[1]Department of Electronic l Engineering, Sir Syed University of Engineering & Technology, Karachi, Pakistan
[2]Department of Software Engineering, University of South Asia, Lahore, Pakistan
[3]Department of Software Engineering, University of Engineering & Technology, Lahore-Pakistan
[4]Department of Electrical Engineering, Computing and Mathematical Sciences, Curtin University, Australia
[5]Department of Electrical Engineering, Sir Syed University of Engineering & Technology, Karachi

ABSTRACT

In many under developing countries the demand of the electricity has been increased rapidly and the cost of the electricity is become very high. The researchers are focusing on cheap energy resources for sustainable future. Only few energy options are available, such as solar power and wind power systems. These systems depend on battery storage system because, if wind speed below desire limits no electricity will generated and same conditions are for solar system, if there will be no sun light or below the desire intensity of light, no electricity can be produced. The commercially available batteries are inefficient and average battery cost 500-1000 US dollars and warranty is around only two years for lead acid battery and three years for dry battery. Previously very limited research work has been done related to topic. The only solution is availability of efficient batteries with low cost and longer life span to address the present issue. Today the demand and utilization of these batteries has been increase so rapidly in many filed such as in energy sector and IoT application. One-way is to improve battery life and efficiency by using Nano coating, Nano wire and Nano batteries. In this paper, the technique presented to improve batteries and storage system for Smartgrid. Also the blockchain technique will be analyzed to control and energy transfer and charging IoT devices efficiently. For analyzing the proposed technique, the matlab simulation tool will be use.

INTRODUCTION

The demand and cost of the electricity has been increase rapidly in recent years. Due to this extra burden now people are searching alternative energy resources for example in Pakistan cost of electricity is very high for a normal person even for good earning salary person, because our establishment take more than 80% plus budget mainly from electricity, petrol and from other all products related to electricity. The public is facing many issues from many years. All these problems are related to job person and rich people are becoming more rich due to white collar man system but these are burden people are sustaining from many years and there is no solution from government side because all governments and civil organizations are under the control of establishment and they will never give relief to poor people to live happily.

In Pakistan there are many issues created by either establishment or political leaders, they all enjoying the facilities but poor people is suffering from these issues from long time. Now it is the duty of Scientists and researcher to device methods to address the electricity issues by using the modern technology [1]. Due to huge cost of electricity people are suffering from bad times. In Pakistan, one way is to install new projects related to renewable energy systems such as wind turbines, solar system and mini hydropower systems. However, one issue is permission and taxes imposed by the government to install new projects is a big issue because the

Government need to take permission from establishment, and they take huge percentage of initial cost to install project via imposing tax. The new vender, often fail to communicate from organization because there are many handles impose by these organizations, which are illegal and cannot support by big international electricity organization.

Due to these issues, many new companies could not install new projects from many years. Now people are installing small solar power system in home range from 1kw to 10KW and this is only solution for poor people of Pakistan. The new cheap solar power systems are required with efficient storage system to facilitate the people. Now researchers and scientists are focusing on new projects based on solar and wind to resolve the issues to fulfill the electricity demand with cheap cost to reduce the financial burden from people. Therefore, the main research should focus efficient and cheap power systems with security. One technique is to increase the efficiency and power of the system is to use the Nano materials, coating and Nano paints to increase efficiency of the system and blockchain to give freedom to users to trade extra generated electricity to any other user in a secure way.

The blockchain technology give freedom to users to sale extra generated electricity to other users in peer-to-peer network instead sale to government organization by using smart meter, which cost around 700 USD dollars [2]. For solar and wind energy system Energy storage system is

essential part and in future the energy storage system must be improve to supply electricity all time. After the introduction of the lithium, batteries at commercial and domestic level, the researcher focusing on Nanotechnology to improve the storage system. The figure 1 shows the block diagram of the Grid model. The inputs of the microgrid are conventional and non-conventional energies. For the storage system, lithium batteries may be used. Now a day in Pakistan with solar system are recommend with set of lithium batteries instead lead battery. The blockchain technology is secure and useful technology to sale electricity in peer-to-peer network.
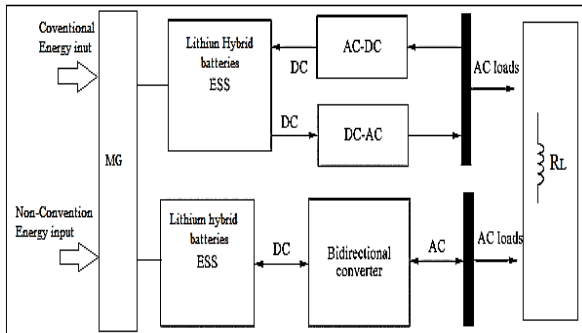

Fig: 1 Energy Storage System model

The unpredictable nature of these systems required efficient energy storage system to provide continuous power such as Super capacitor and lithium batteries. Now researchers and scientists are focusing on new projects based on Blockchain, IoT bigdata and Nano sensors. The Nano technology playing vital role increase the efficiency and power of the system by using Nano materials, coating and Nano paints. The blockchain and IoT network has many applications in medical and energy sectors. The blockchain technology is secure and useful technology in many sectors. [18].

LITERATURE REVIEW

In this research paper, the author used the model of distributed generation to analyzing the energy storage system (ESS) capacity; size of the storage system by sung the PV solar system [3]. In this paper the author, analyze the power system IoT based of micro grid using distributed power system. The focus was on power distribution system using microgrid algorithm with minimum utilization of power with minimum losses [4]. The storage system capacity and performance depend on the load and the battery construction parameters, materials. In this research article author, calculate the performance of solar power system with battery storage using two modules with standalone mode [6]. The result shows the performance of system goes down due to ambient temperature but no solution to improve temperature suitability. In this article, the improvements in energy storage presented with storage and CO2 reduction targets. The Super capacitor are shown the as an important part of the solution. Supercapacitor could charging electric vehicles much faster

than using lithium-ion batteries. However, more Supercapacitor development is needed to enable to store effectively more electricity [7]. In this report the author explain about the new batteries and applications of these batteries, the life of the new batteries are more and its low carbon based [8]. Microgrid is taking more attention in recent years due to the many benefits, such as reduction of voltage fluctuations, increasing reliability, power quality improvement, energy cost reduction, and ultimately increasing customer satisfaction. However, some issues are still need to address such as changing the protection setting, power system stability, and working in islanding mode [9]. In this paper the author explains the benefits of the Blockchain technology using trading the energy [10]. In this paper the author presents the basic techniques of the energy converting devices and the potential of the system. The impact of the system not affects the marine life or any other issue. It is safe and clean energy and has many benefits [11]. In this paper the author, present the benefits of the blockchain for energy storage system. By using the blockchain, the energy can be trade more efficiently and more profit cab is generated [12]. In this paper the author explains the benefits of the Blockchain technology using trading the energy [13]. In this paper the author presents the basic techniques of the energy converting devices and the potential of the system. The impacts of the system not affect the marine life or any other issue. It is safe and clean energy and has many benefits [14]. In this paper the author, present the benefits of the blockchain for energy storage system. By using the blockchain, the energy can be trade more efficiently and more profit cab is generated [15]. In this paper author presented traffic model for smart city for vahicles using IoT and sensors[18].

ADVANCE ENERGY STORAGE SYSTEMS (ESS)

The commonly available energy storage systems are lithium and lead batteries in the market. These are cheap at low loads but expensive for high loads requirements. There are many benefits related with energy storage systems in power systems such as losses and stability while interconnecting the new loads, but some critical issues such as changing the protection setting, power system stability, and islanding mode must be address. In microgrid the energy reached at different recourses and levels from renewable resources such as wind and solar power plants, or nonrenewable resources (conventional methods), but the main issues are changeability and uncontrollability of output power. Microgrid is often propose with Energy storage system (ESS) and it is one of the perfect solutions. The required amount of electricity that should be transmitted through transmission lines can be reduced using storage system because it helps to share the peak energy demands. Nanotechnology will play vital role in energy generation system through the development of low cost devices required to store the electrical energy such as fuel cells, batteries and capacitors. Nano materials may optimize the future energy

storage devices by using Nano scales catalyst particles. In future storage system would be essential part of the power supply system in future to fulfill the energy needs. Some storage systems are given below. To operate the power system optimally the charging period and the discharging period in the peak times in stored energy must be improve. In the author discuss the advanced lithium-ion battery and a claim shows good performance at high temperature, it also has a much longer lifetime no hazardous materials issues [16]. In this paper author explain the features of Nano wire batteries and claims by using these batteries EBP and uninterruptible power supply can be provided to distributed mini-grids [5]. In present the conventional grid, the storage system is limited such as pumped hydro-storage, which are mainly in mountainous areas but other storage system such as batteries, electric cars, flywheels, hydrogen, chemical storage implemented in small scale.

In future storage system would be essential part of the power supply system to fulfill the energy needs. Some storage systems are given below for future power system.

NANO-BATTERIES

A carbon nanotube has good electrical conductivity and has high surface areas. The surface areas of carbon nanotubes are highly accessible to a battery's electrolyte due to their linear property. Carbon nanotubes based electrodes used this linear property in batteries to get more electricity output than conventional electrodes. It is possible because for a given amount of material, the energy output can be increase due to this linear property and batteries will become more powerful, as well as size of the batteries will be smaller and weight will reduce for a wider range of applications. The nanostructured materials will also increase the battery life about 10-20 times than present age lithium batteries and battery will provide good performance over a wide range of temperatures over currently used batteries. Approximately 70% or more power would be available at temperature range of $-45°$ to $+152$ °F.
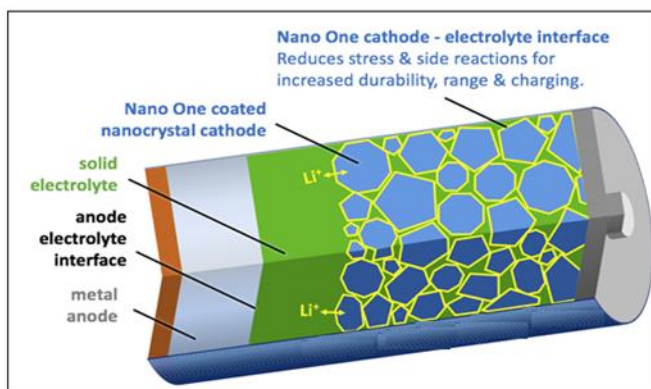

Fig: 2. Nano Batteries

The advanced lithium-ion battery are performing good at high temperature, it also has a much longer lifetime

no hazardous materials issues as given in figure 1. By using these batteries EBP and uninterruptible power supply system has become consistent part of distributed mini-grids [17].

ADVANCE CAPACITORS

From recent research, it has been discover that capacitor electrodes surface area and capacity to store electrical energy can be enhance by using millions of nanotubes [18]. The new technology is combining the strength of conventional batteries with longer life, speed of capacitors and adding more applications for battery connected device.

NANO FUEL CELLS

Dominant fuel cells compared to available now a days based on innovative materials design concept. Manipulation and control of new material structure at Nano scale results in efficient fuel cells. Nano scale structured devices enhance energy extraction efficiency from carbon-neutral and fossil fuels. Efficient direct utilization of biogas and natural gas is possible by using new electrode material in fuel cells as shown in the figure 3.
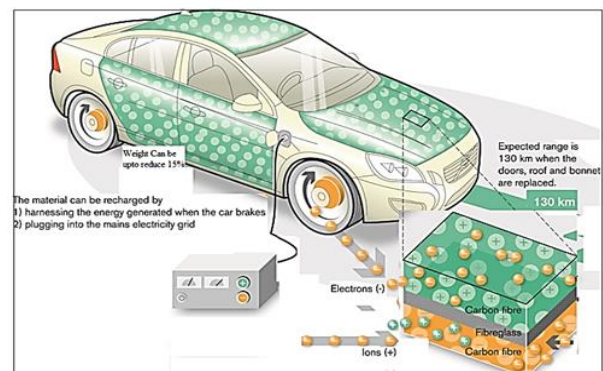

Fig: 3. fuel cell based car

Transportation applications where durability is the major concern, composites components that can be deploy in fuel cell. In these composite components carbon nanotubes used that have toughness-to-weight and high strength characteristics. Applications of energy storage system are given in table 1.

ISSUES AAND CHALLENGES

There are following issues and challenges such as:
a. Improving the Energy storage system and life span.
b. All components related with energy storage system converter, power components must have fast switching time to transfer energy efficiently.
c. Storage capacity must be increase
d. The cost should be low.
e. A more efficient system need to develop, which should be intelligent, time efficient and dynamic to address these issues above issues using storage system.
f. The size of the storage system must decrease.

In this research work, three major issues related to

theblockchain system will be address such as, blockchain model for Energy Trading and losses control using efficient energy storage system and algorithm to find shortest path for utilization of energy and trading in network as given in figure 7.

Table 1: Types of Batteries Merit and Demerits

Battery type	Features	Merit/demerit		
Metal Air	High energy density	Need Charging		Yes
NaS	Both energy density and efficiency high	Cost High,safety problems	Yes	yes
Li-ion battery	High power energy Density and high efficiency	High production cost, need special circuit charging	yes	Not feasible But economical
Ni-cd battery	High power energy Density and high efficiency	Power Limitation	yes	partial
Lead Acid	Low cost	Short life	yes	Not suitable But cheap
Fly wheels	Power High	energy density Low	yes	Not feasible But economical
SMES, DSMES	Power High	energy density Low cost high	Yes	
E.C. Capacitors	Long life Efficiency High	Density Low	yes	partial

BLOCKCHAIN AND ENERGY STORAGE SYSTEM

Energy storage needs to integrate in electrical grid system. Energy storage is essential part of microgrid integration with CHP, solar thermal and wind energy systems to balance the power supply system. In future, an efficient energy storage system is required to exchange the stored energy in real time energy exchange. The block chain supports transaction based distributed ledgers. The blockchain technique can used to increase the profitability and minimize the project risk. The Blockchain ensure the profit and handle process secure transection in the network. It can measure the amount of energy stored and generated by the renewable energy resources. It can also ensure about the Production process and provide information that no CO_2, emission in process.

Blockchain provide secure transition between prosumers and banks. It also provides the information regarding usage of renewable energy resources to all prosumers in the network in real time. The application of advanced batteries is given in figure 4.
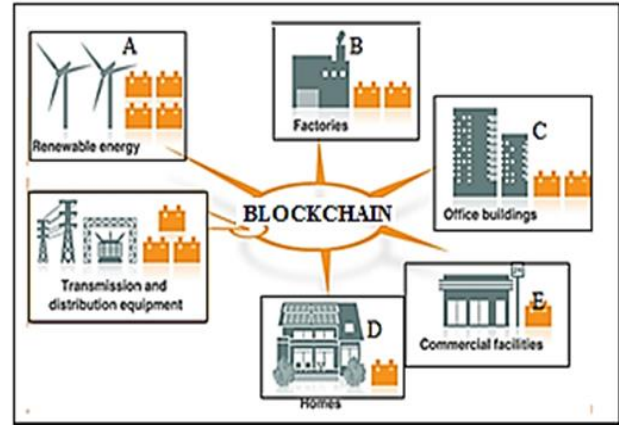

Fig: 4. The application of advance batteries

Battery storage is a key ingredient in maintain Microgrid stability and extra energy return to the grid and stored in system and provide on demand using Blockchain technology. Moreover, provide uninterrupted power supply.

PROPOSED ENERGY STORAGE SYSTEM

Energy storage system can use in all networks such as IoT application and medical field at any locations. The Energy storage method is shown in figure 5. The figure 6 presents the storage system. The type and size of storage system should be large and bulk such as:

a. Thermal storage
b. Compressed storage system
c. Chemical storage system

Grid with storage systems can be used the following devises such as:

a. Super capacitors, Superconducting Magnetic Energy Storage and flywheels
b. Li-ion, NaS Batteries, etc
c. For energy Li-ion batteries can be used
d. Hydrogen Storage (fuel cell)/ CAES / (PHES) (small scale)

For home user the energy storage systems are:

a. Flywheels, super-capacitors
b. for energy the batteries such as Li-ion batteries and Lead acid batteries
c. For both Energy and Power: Li-ion batteries are preferred The Table 8.1 shows the complete details of storage system.

The equation for smartgrid power system is as follows:

$$P_{Load}(t) = P_{pv}(t) + P_{Grid}(t) + P_{batt}(t) \qquad (1)$$

From equation 1, the total load power is equal to the solar, grid and battery it can be seen that battery power can play important role in the system.
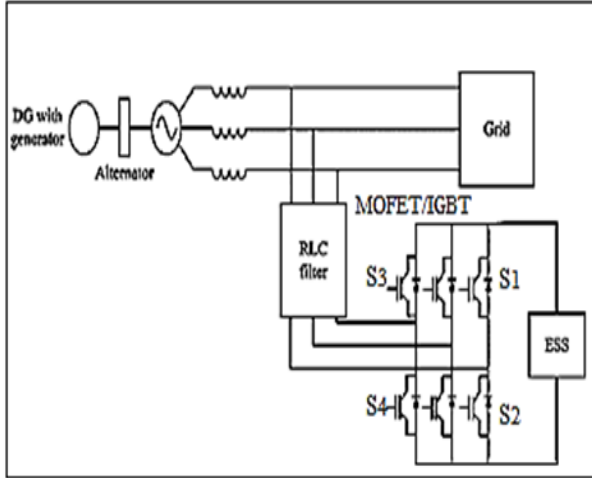
Fig:5. Energy storage circuit

In above figure 6, the energy storage circuit is given for grid. By using the advance switching components of fast speed the energy transfer time can be reduced.
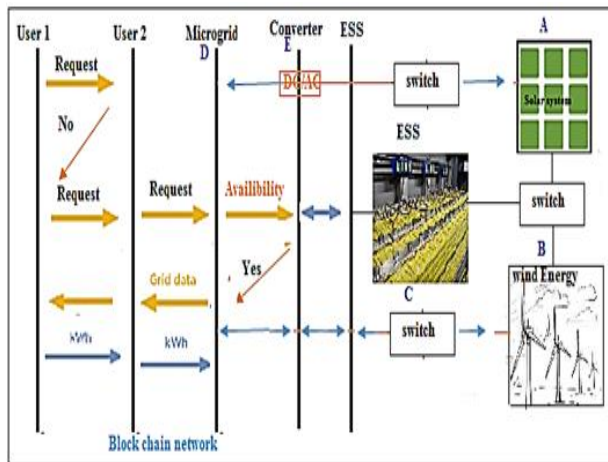

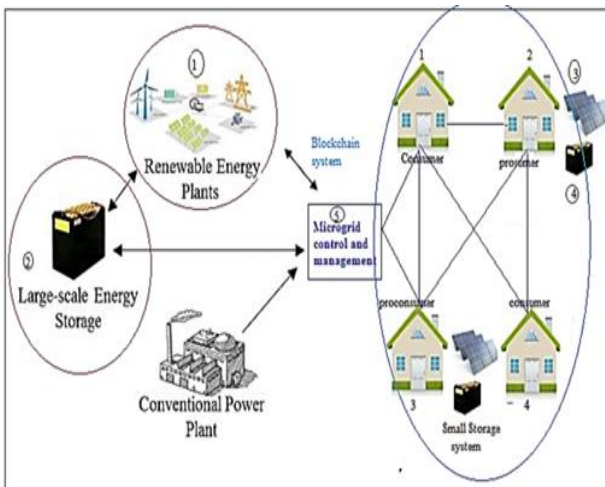Fig: 6. the method of energy storage in grid

Fig: 7. Proposed system

In following section the proposed solution to the above issues will be present;

EFFICIENT ENERGY STORAGE SYSTEM

In smartgrid efficient energy storage system play significant role to provide uninterrupted power supply. There should be no delay between input and output system ideally. The lithium batteries show the best efficiency with minimum cast. It gives surety that energy will be available for the users all the time. In addition, it can reduce carbon footprint. In table 1, three energy systems are focus with the recommendation of energy storage system.

Table 2: Energy Storage Systems

RES (Solar energy)	Wind Turbine	FC	ESS
Solar	Micro-range wind power generation	Stationary fuel cells	high-capacity battery
Solar photovoltaic	High-power range WT	SOFC fuel cells	Magnetic storage in superconducting coils Capacitors
PV: Nano- 3D-structured	Large-scale offshore wind (transfer & storage	Soli d-oxide fuel cells	Flywheel energy storage
Solar thermal	--	MCFC fuel cells	Compressed-air and electricity storage
PV (the rest) Nuclear power	--	PEMFC fuel cells Heat pumps	High-power permanent magnet motors Battery for EV ,

ENERGY TRADING AND LOSSES CONTROL USING BLOCKCHAIN USING MICROGRID MODEL

In recent years, many users are generating its own energy by installing solar and small wind turbines in homes but there is no method in Asian countries as in Pakistan for sell/buy energy in peer-to-peer network is available or from MG. only method is to sale electricity to government electricity companies with low rates. Old grid system has no self-healing algorithm such as in microgrid. In microgrid, transmission lines losses related with the price directly because losses in the transmission line directly related to the price of Solar system is lowest, which must be Increase.

IMPLEMENTATION OF PROPOSED METHOD AND RESULTS

To improve batteries efficiency and storage capacity for small IoT devices and industrial applications, nanowire and coating methods are used and Titanium and zinc oxide Nano materials in focus. Nano batteries can be used in the system. The Below the flowchart Figure 8, use method to Integrating the energy and storage, which can use by microgrid to buy and purchase energy in the network. The energy can be integrated based on rate and carbon foot print option in microgrid to buy and sell energy in the network.
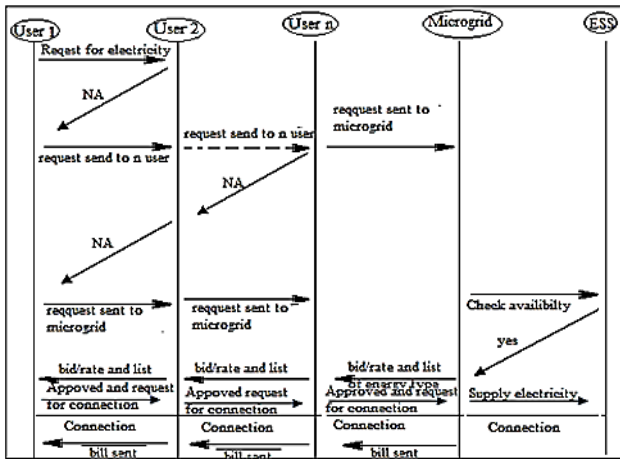
Fig: 8. Flowchart of the proposed system

The Energy storage system depend on size and capacity and application such as small, medium and large scale for example pumped storage, compressed air system (CAES), flywheel and superconducting magnetic energy storage (SMES). Use for high capacity ranges.
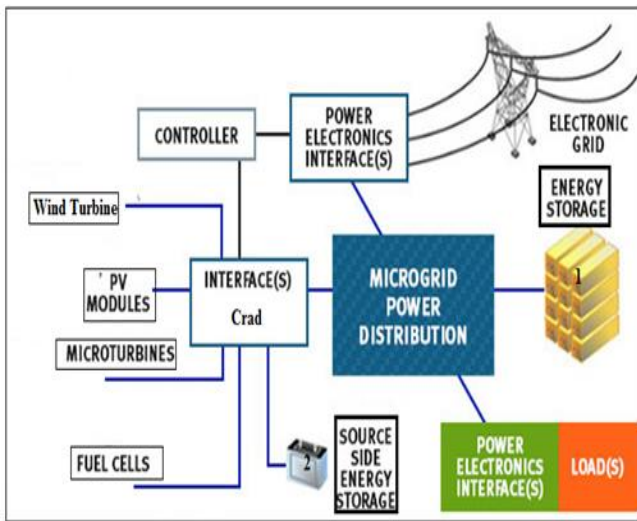

Fig: 9. Microgrid model with energy storage system

In figure 9, the Microgrid model with ESS is given. The input energy resources are conventional and non-conventional.

The figure 10 flowchart shows the energy management plan for IoT devices by using the blockchain in Smartgrid, the remaining stored energy from one domain shift other domain with secure system in the grid. The benefits of the storage system are given in figure 11 below. The two-energy storage system shown, one at small level and other is at large scale.
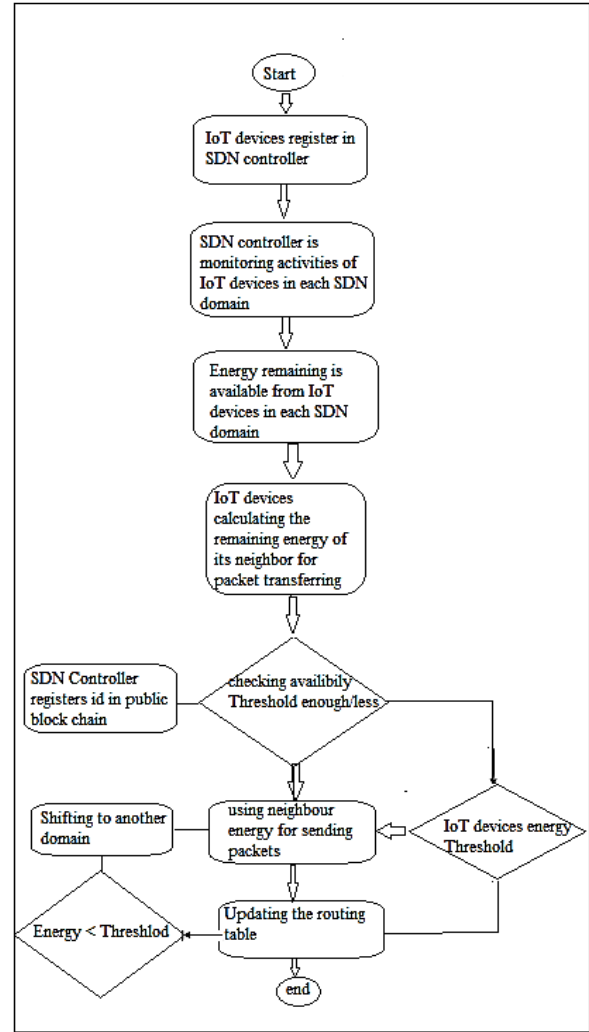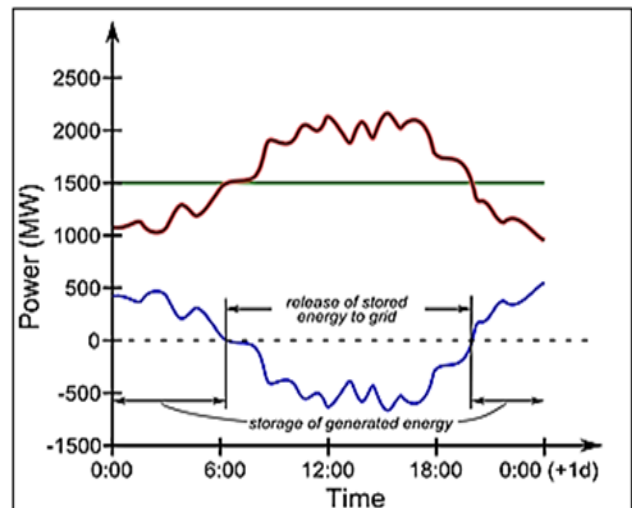

Fig: 10. Flowchart of Proposed system.

Fig: 11. Benefits of Energy storage system

From the figure, it can be concluded that with energy stored system smooth power can be provided to consumers without any interruption. The green line shows system with battery and red line with no storage system. This energy sharing model work efficiently in small networks.

CONCLUSIONS

In this research work, the major issue related to energy storage system was investigated and suitable solution proposed. The result shows that by using proposed methods the losses can reduce and efficiency can be increased of new advance storage system. Energy storage system is essential part of smartgrid and IoT in advanced power flow management. The energy storage system can be used to minimize the variations in the system, reduce the blackout time with no additional charges on customers. Major benefit of Energy storage system can provide off-grid operation unless the other main power generation from main sources such as hydel power, generators are not available. Energy storage capacity can be improve and charging discharging times can be reduce by using efferent, inverters, controller's functions by using Nano electronics components as mention in paper. It can also provide alerts such as about maintenance requirements and fault generation. Energy storage can control the peak demand and losses more accurately by using the blockchain. Nanomaterials can be used to improve the energy storage capacity of IoT devices such as lithium batteries to store large amount of energy power for longer times though optimized electrodes and electrolytes materials.

FUTURE WORK

The present model was proposed for small network system for IoT devices sharing stored energy using the blockchain. For wide area network this model can be tested using advance batteries and storage system to share more energy in the multiple domains with decentralized blockchain technology.

ACKNOWLEDGEMENT

First it is my great pleasure to say thanks to advisor for his guidance and important time for advising and guiding me. Then I must say thanks to all my friends and colleagues for moral support and time and finally to my family for moral support.

CREDIT AUTHOR STATEMENT

Fahad Ahmad Sadiqe: Methodology, **Afshaar Ahmed**: Conceptualization, Software, data curation, Writing- Original draft preparation. *Lubna Farhi*: Visualization, Investigation. *Mishaal Ahmed* Software Supervision**: Manzar Ahmed**: Software, Validation.: **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.

REFRENCES

[1] M. Andoni, V. Robu, D. Flynn, S. Abram, D. Geach, D. Jenkins, P. McCollum and A. Peacock, "Blockchain technology in the energy sector: A systematic review of challenges and opportunities", Renewable and Sustainable Energy Reviews, Volume 100, Pages 143-174, 2019.

[2] J. J. Ochoa, G. Bere, I. Aenugu, T. Kim, K. Kwang and R. Choo, "Blockchain-as-a-Service for Battery Energy Storage Systems", IEEE Explore, Power and Energy, 2020.

[3] P. Cong, N. Truonga, M. Schimpea, U. B. bholger, C. Hessea and A. Jessenia, "Multi-Use of Stationary Battery Storage Systems with Blockchain Based Markets", Science Direct, Energy Procedia, Vol 155, pp 3-16, 2018.

[4] A. M. Omar and M. M. Mahmoud, "Design and Simulation of a PV System Operating in Grid-Connected and Stand-Alone Modes for Areas of Daily Grid Blackouts", International Journal of Photo energy, Vol 9, 2019.

[5] H. Mostafa, A. Moataz and Y. Abdelaziz," Energy management solutions for microgrid", Journal Distributed Energy Resources in Microgrid, 2019.

[6] D. Voumick, P. Deb, M. M. Jaman, "Operation and Control of Microgrid Using IoT (Internet of Things)", Journal of Software Engineering and Applications, Vol.14 No.8, 2021.

[7] N. Z. Aitzhan and D. Svetinovic, "Security and Privacy in Decentralized Energy Trading through Multi-signatures, Blockchain and Anonymous Messaging Streams," IEEE Trans. Dependable Secure Computer, pp. 1-2, 2016.

[8] T. Alskaif, Jose L. C. Vazquez, M. Sekuloski, G. V. Leeuwen, P. S. Catalão, "Blockchain-Based Fully Peer-to-Peer Energy Trading Strategies for Residential Energy Systems", IEEE Transactions on Industrial Informatics, Vol 18, pp 231- 241, 2021.

[9] A. S. Yahaya, N. Javaid , S. Ullah, R. Khalid, M. U. Javed, R. U. Khan , Z. Wadud, and M. A. Khan, "A Secure and Efficient Energy Trading Model Using Blockchain for a 5G-Deployed Smart Community", Wireless Communications and Mobile Computing, 2022.

[10] M. K. Hasan, A. A. Khalifa, S. Islam, N. B. M. Babiker, A.H. Habib, A. H. M. Aman and M. A. Hossain, "Blockchain Technology on Smart Grid, Energy Trading, and Big Data Security Issues, Challenges, and recommendations", Metaheuristic Algorithms for Big Data Analytics within the Internet of Things, Special Issue, Vol 2022, 2022.

[11] L. Hongbiao, F. Xiao, L. Yin and F. Wu, "Application of Blockchain Technology in Energy Trading", Frontier Energy, 2021.

[12] N. Mhaisena, N. Fetaisa and A. Massoud, "Secure smart contract-enabled control of battery energy storage systems against cyber-attacks",

[13] S. Baily "Hidden Behavior of Supercapacitor Materials Revealed", Journal of AZO Materials, Nov 10 2021.

[14] Hironori Kodama, "Energy Devices and Systems", Hitachi chemicals, report no 57, institute of Electrical Engineer, Japan, 2012.

[15] L. Hang, and D. Hyeun Kim, "Design and Implementation of an Integrated IoT Blockchain Platform for sensing data integrity", sensors, pp 10-19, 2019.

[16] M. Ahmed, A. M. khan, M. Ahmed, M. Javeed, L. Farhi, I. Ul. Haque, "Energy Trading and Control in Microgrid Network by using Blockchain Technology", VFAST Transaction on software Engineering, Vol 10, No, 1, 2022.

[17] Amin S. Ibrahim, Khaled Y. Youssef, Ahmed H. Eldeeb, Mohamed Abouelatta, Hesham Kamel, "Adaptive aggregation based IoT traffic patterns for optimizing smart city network performance", Alexandria Engineering Journal pp 9553–9568, 15 March 2022.

[18] Amin S. Ibrahim, Khaled Y. Youssef, Hesham Kamel, Mohamed Abouelatta, "Traffic modeling of smart city internet of Things architecture", Institute of Engineering & Technology Journal, 2022.