Uses of Block Chain Technology in Redesigning Power Market for High Level of Renewable Energy in India

Sanjay Prakash Bhagat
Scientist C, Ministry of New and Renewable Energy
Government of India,
Block 14, CGO Complex, Lodi Road, New Delhi, India
Email: spbhagat.mnre@gov.in

***Abstract*— Blockchain is a decentralized ledger technology. When applied to the energy sector, it will enable people to trade energy among themselves. It is a secure, continuously growing list of records. It is constructed as a decentralised database that is distributed and managed by peers, rather than by a central server or authority. This technology is enabling a new world of decentralised communication and coordination, by building the infrastructure to allow peers to safely and quickly connect with each other without a centralised intermediary. Cryptography ensures security and data integrity, while privacy remains intact. Renewable Energy is also decentralized and distributed energy source. Currently, efforts are made to integrate Renewable Energy in the grid for centralized control of Renewable Energy. This is because there is no technology available to manage and control distributed and decentralized Renewable Energy. Block Chain may provide tools to manage it locally. This may be possible for peer to peer trading of electricity produced from Renewable Energy without using any middleman. The general idea behind blockchain technology is to allow decentralisation and build security. The advantages of blockchain are increased trust and minimization of time for a process to take place. Moreover, it also removes cost overheads and intermediaries. India has set an ambitious target of 175 GW of RE in energy mix by 2022. Almost 40 percent of target has been achieved, these high level of RE in electricity mix will certainly change the way Indian Power Market Operates. This paper finds a way to formulate a power market with high RE in electricity mix in India using blockchain technology.**

Keywords- Block Chain technolo, Renewable Energy, Power Market, Smar Contract

Introduction

In current scenario in India, Power Trading/Open Access allows consumers to purchase electricity directly from power generators or energy exchanges. This increases the competition in the market and it ultimately benefits the consumers. Open Access bridges the gap between Deficit energy and Surplus energy. This not only reduces staggering but also improves the electricity distribution scenario. Open access allows consumers to avail electricity through the already existing infrastructure of State utilities (open access charges need to be paid). Many states including Punjab, Haryana, Gujarat, Chatisgarh have already implemented this policy wherein bulk consumers have been given permission to purchase electricity through open access. However, as a part of Intended Nationally Determined Contributions (INDCs), India has committed to increase the share of installed capacity of electric power from non-fossil-fuel sources to 40% by 2030. The Cabinet had approved Renewable Energy target of 1,75,000 MW by 2022.In this majority of power 1,60,000 MW has been envisaged to come from Wind and Solar Energy. Approximately 40, 000 MW is set as target from Roof Top Solar which will be decentralized and intermittent. Peer-to-Peer (P2P) energy trading is a new paradigm of power system operation, where energy can be generated from Renewable Energy Sources (RESs) in houses, offices and factories, and trade it with their peers nearby. This is contrary to earlier mechanism of centralized electricity trading through exchanges. When the power system is being decentralized, it is required to think beyond what is getting practiced today.

Blockchain is a decentralized ledger technology. When applied to the energy sector, it will enable people to trade energy among themselves. Blockchain will enable a fundamental shift in the distribution of energy. Block Chain facilitates energy trading that will stimulate more renewable energy projects as a whole, ultimately forwarding our transition from carbon-emitting electricity generation. Tokenizing renewable energy allows wind, solar and hydro producers to seamlessly connect with investors, who are willing to pay upfront for the right to consume renewable energy. As a distributed system, the middleman is removed.

Blockchain makes a new energy sharing economy possible, one that facilitates an open exchange of power between homes, with all transactions recorded through a decentralized ledger. This will represent a fundamental change in the way electricity is generated, used and distributed for the better. Its promise will empower to determine the impact on homes and on climate. Today, grids have become increasingly complex, with increasing shares of variable distributed generation (such as rooftop solar), increasing numbers of internet-connected devices (such as smart appliances), and increased loads from the influx of electric vehicles. Blockchain can help operate power grids with high penetration of variable distributed generation and flexible demand-side resources in a more efficient, automated way, all with lower transaction costs. Blockchain can allow system operators of distributed generation to optimise grid operation by managing all connected devices through automated smart contracts, enabling flexibility and real-time pricing. Blockchain also empowers consumers to become ‘prosumers’ by enabling them to monetise their excess electricity (generated by rooftop solar for example) by securely recording data and sending and receiving payments automatically, through smart contracts. Few early signs of international adoptions for blockchain in energy tradings are Singapore’s launch of a sandbox for energy

innovations and new legislation in US states like Vermont to help apply blockchain technology.

On 29th October, 2018, major Singapore utility SP Group has launched a blockchain-powered renewable energy certificate (REC) marketplace, which is amongst the first of its kind worldwide. The platform allows local and international bodies of any size and in any location to trade in RECs related to a range of renewable energy sources. The use of blockchain technology allows buyers to be automatically matched with sellers around the globe according to their preferences. Blockchain also serves to ensure the security, integrity and traceability of each REC transaction, which will then help spur even more integration of renewable energy onto the grid.

Blockchain is a foundational technology that can be used to create new business models and underpin business, economic, and social infrastructure. While many Blockchain use cases have been proposed for the energy industry, the one gaining the most traction at present is peer-to peer (P2P) power trading, where owners of small-scale generation can sell excess generation directly to other consumers. Today, centralized control of distributed energy resources (DER) restricts to whom and when DER owners can sell their energy back to the grid. A Blockchain enabled P2P model allows much greater flexibility and could be a powerful enabler for a customer-centric transactive energy regime. To support the development of Blockchain-based solutions for the energy sector, a lot of organizations are setting-up Blockchain Labs with the aim of accelerating new Blockchain applications such as distributed ledger solutions and its use-cases.If the new applications are successful for mass adoption, it would have profound impacts on the business models of the entire energy sector value chain.

Europe is the most active region for the Blockchain pilots, with utilities working on EV charging, connected home, wholesale settlement and lab creation efforts. Currently, in Germany many Blockchain pilots are in various stages of progress. The world's first P2P energy transaction took place in New York City in 2016. In the first quarter of 2017, the DoE issued a tender for Blockchain projects with a focus on security. In South Africa, Sun Exchange connects investors to businesses and communities who need access to affordable electricity. In China, Wanxiang is planning to invest $30billion in a Blockchain backed Smart City Project. Power Ledger, a startup in Perth, Australia is working on multiple projects across the region. In a pilot in Netherlands, Vandebron will work with customers who own an EV to make the capacity of their car batteries available to help the grid operator balance the grid while protecting the battery life. The Blockchain will enable each car to participate by recording its availability and action in response to signals from the grid operator.

Blockchain is still in its early stages for Renewable Energy and new applications and advancements are regularly occurring. Big changes are expected over the next few years in the energy industry as more and more companies are using Blockchain creating a business case and building a startup team for this disruptive technology. India has set an ambitious target of 175 GW of installation of RE by 2022. In that, major chunk is envisaged to come from decentralized generation of Renewable Energy. India should start to explore uses of block chain technology in Renewable Energy sector.

INDIAN RENEWABLE ENERGY AND USES OF BLOCK CHAIN

Largely three areas where Block Chain Technology may be used in India 1. Rooftop Solar 2. Development of MiniGrid with renewable Energy including Solar Pumps 3. Renewable Energy Certificate Mechanisms

ROOF TOP SOLAR AND USE OF BLOCK CHAIN TECHNOLOGY

In a centrally organized electricity sector, consumers are passive participants. Solar Roof Top power system made consumers of electricity also producers of electricity. So they are not only consumers but also suppliers of electricity and hence the role of all stakeholders like high voltage level transmission and low voltage level distribution need to be redefined in the existing power market structure. In this scenario, Block Chain technology may provide a mechanism to trade renewable energy through using Smart Contract, introducing Crypto Coin as Solar Coin based on output of solar energy produced. This can be achieved using aggregator or without using it. However, rooftop solar power plant having capacity less than 100kWp shall participated only through aggregator. Smart Contract needs to be designed in such a way that prosumers will participate in Renewable Energy market with benefits. Blockchain is the mechanism that allows transactions to be verified by a group of unreliable actors. It provides a distributed, immutable, transparent, secure and auditable ledger. The blockchain can be consulted openly and fully, allowing access to all transactions that have occurred since the first transaction of the system, and can be verified and collated by any entity at any time. The blockchain protocol structures information in a chain of blocks, where each block stores a set of Bitcoin transactions performed at a given time. Blocks are linked together by a reference to the previous block, forming a chain.To support and operate with the blockchain, network peers have to provide, the following functionality: routing, storage, wallet services and mining. According to the functions they provide, different types of nodes can be part of the network. The routing function is necessary to participate in the P2P network, this includes transaction and block propagation. The storage function is responsible for keeping a copy of the chain in the node (the entire chain for full nodes, and only a part of it for light nodes).Wallet services provide security keys that allow users to order transactions, i.e., to operate with their Bitcoins. Finally the mining function is responsible for creating new blocks by solving the proof known as miners, and they receive newly generated bitcoins, and fees, as a reward. The concept of proof of work is one of the keys to enable trustless consensus in blockchain network. The proof of work consists of a computationally intensive task that is necessary for the generation of blocks. This work must be complex to solve and at the same time easily verifiable once completed. Once a miner completes the proof of work, it publishes the new block in the network and the rest of the network verifies its validity before adding it to the chain. Since the generation of

blocks is carried out concurrently in the network, the block chain may temporarily fork in different branches (produced by different miners). This discrepancy is solved by considering that the longest branch of blocks is the one that will be considered as valid. This, together with the intensive nature of the block generation process provides a novel, distributed-trustless-consensus mechanism. It is very computationally expensive for a malicious attacker to modify a block and corrupt the block chain since the rest of the trusted miners would outrun the attacker in the block generation process and therefore the trusted branch of blocks will invalidate the one generated by the attacker. In technical terms, in order for a manipulated block to be successfully added to the chain, it would be necessary to solve the proof of work faster than the rest of the network, which is computationally too expensive — it requires having control of at least 51% of the computing resources in the network.

Due to the large computational capacity needed to modify the blockchain, the corruption of its blocks is practically impossible. This means that, even if the participants are not completely honest about the use of Bitcoin, a consensus is always reached in the network as long as most of the network is formed by honest participants. Blockchain could enable

the development of prosumers as market participants by facilitating Peer to Peer (P2P) electricity supply, the direct transaction between a producer and a consumer in the electricity sector. Essentially, this would extend the market realm to the current consumer level and ideally facilitate the efficient exploitation of decentral RES sources which are currently rather perceived as burdensome and not well integrated in the electricity market. The application of blockchain as enabler of P2P supply is implemented and tested by the Australian company "Power Ledger". Despite the fact that the company is based in Australia, insights in blockchain-based P2P electricity supply can serve as relevant source beyond the Australian context, for example in India. Essentially, the company establishes a market platform especially for RES enabling decentralised transactions among producers, consumers, and those who

do both. The platform promises

"[…] to simply trade electricity with one another and receive payment in real-time from an automated and trustless reconciliation and settlement system. There are many other immediate benefits such as being able to select a clean energy source, trade with neighbours, receive more money

for excess power, benefit from transparency of all your trades on a blockchain and very low-cost settlement costs all leading to lower power bills and improved returns for investments in distributed renewables."

The platform of "PowerLedger" is composed of different interrelated technology layers, which apply two different blockchain designs. One is permissionless and operates globally; this allows anyone to invest in the platform by buying market access. The other one is a permissioned blockchain (consortium design with several parties as trusted nodes), which operates as trading platform for peers. The best part of Block Chain technology is that there is no role of Middle Man in overall trade. It is required to evolve a policy and regulatory mechanism for the uses of Block Chain Technology in roof top solar promotion in India.

DEVELOPMENT OF MINIGRID WITH RENEWABLE ENERGY INCLUDING SOLAR PUMPS

Government of India notifies guidelines for implementation of Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) Scheme. By this Scheme, the Government of India has launched New Scheme for Farmers with following components:

i. Component-A: Setting up of 10,000 MW of Decentralized Ground/ Stilt Mounted Grid Connected Solar or other Renewable Energy based Power Plants;

ii. Component-B: Installation of 17.50 Lakh Stand-alone Solar Agriculture Pumps; and

iii. Component-C: Solarisation of 10 Lakh Grid Connected Agriculture Pumps.

The basic plan for implementation is the Component-A and Component-C will be implemented initially on pilot mode for 1000 MW capacity and one lakh grid connected agriculture pumps respectively and Component-B will be implemented in full-fledged manner with total Central Government support of Rs. 19,036.5 Crore. After successful implementation of pilot project of Components A and C, the same shall be scaled up with necessary modifications based on the learning from the pilot phase with total Central Government support of ₹15,385.5 Crores. All three components of the scheme aim to add Solar capacity of 25,750 MW by 2022 with the total Central Financial Support of ₹ 34,422 crore. Grid Connectivity and effective and optimum incentive to farmers will be major challenges in the implementation of this scheme. Block Chain mainly named "Kisan Mudra". "Kisan Mudra" will be a crypto coin based on Block Chain Technology."Kisan Mudra" will be used for all three components of this new farmer's scheme.

RENEWABLE ENERGY CERTIFICATE MECHANISM

Renewable energy sources are not spread evenly across the state boundaries and the high cost of generation from RE sources discourages local distribution licensees from purchasing electricity generated from RE sources. Renewable Energy Certificate seeks to address the mismatch between availability of RE sources and the requirement of the obligated entities to meet their renewable purchase obligation by purchasing green attributes of renewable energy remotely located in the country. Renewable Energy Certificate (REC) mechanism is a market based instrument to promote renewable energy and facilitate renewable purchase obligations (RPO). REC mechanism is aimed at addressing the mismatch between availability of RE resources in state and the requirement of the obligated entities to meet the renewable purchase obligation (RPO). Cost of electricity generation from renewable energy sources is classified as cost of electricity generation equivalent to conventional energy sources and the cost for environmental attributes. RE generators will have two options: i) either to sell the renewable energy at preferential tariff or ii) to sell electricity generation and

environmental attributes associated with RE generations separately. The environmental attributes can be exchanged in the form of Renewable Energy Certificates (REC). • There shall be two categories of certificates, viz., solar certificates issued to eligible entities for generation of electricity based on solar as renewable Cost of Electricity Generation by Renewable Sources Cost Equivalent to Conventional Source Cost for Environmental Attributes and non-solar certificates issued to eligible entities for generation of electricity based on renewable energy sources other than solar. In the similar line instead of issuing REC Solar Coin and Non Solar Coin may be developed using Block Chain technology.

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