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Use of Blockchain Technology in Energy Banking and Electricity Markets

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Abstract

Power system reforms worldwide have commoditized electric energy, and thus the electricity market has been developed. With this, trading of electric energy takes place in various time-domains like the day ahead, real-time, etc. These transactions take place over the counter (OTC) or Power Exchange (Px), which provide the market participants with the required platform and payment security. The transactions on OTC and Px requires a third-party platform and guarantee for contract and settlement, there incurs overhead cost. Since electric energy is a fungible commodity, it can be transacted very well with the old system like barter. Energy Banking is one such mechanism wherein one utility supplies the energy to another utility that needs it more and, in leisure, the energy can then be provided back. The requisite security of the transactions can be provided by blockchain technology. Energy banking is presently being done only on a MW quantum basis with no price tag, despite the cost being dependent on the demand-supply ratio. To ensure energy banking transactions in real-time and free from the perils of financial settlements, this article suggests the use of the Peer-to-Peer (P2P) model of blockchain technology for executing Smart Contracts mutually agreed upon by both parties and avoiding third party overhead costs.

Keywords: P2P Model; Smart Contracts; Blockchain; Energy Banking; TBCB; DLT; TIU.

1. Introduction

Energy banking in the electricity sector is still in a nascent stage despite being an age-old concept. The merits of this mechanism are not being utilized to the fullest rather the orthodox method is making this obsolete. This article proposes a modernized way of carrying out the energy banking mechanism by utilizing blockchain technology in Section 2. This not only ensures trustless transactions but with Smart Contracts as an added layer of blockchain helps in stretching the energy banking concept from two parties to a multi-party system.

This article also proposes the method of bidding for energy banking, utilizing smart contracts and blockchain technology in Section 4. Banking on power or energy banking [1] means the exchange of electricity for electricity (instead of money). In India, due to geographical and seasonal diversity, the power requirement varies heavily between states. Due to these diversities, it is always a herculean task to devise a balance between the demand and generation requirements of a state. In India, there are two prevalent methods of energy banking: firstly, through mutual consent, and secondly, through competitive bidding. Some hydro-rich states have executed energy banking agreements through MOU (Memorandum of Understanding) on mutual consent and some have adopted the competitive bidding route. The

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electricity utility (say, Utility A) has surplus power in the winter season demand, but the same generation capacity could not cater to its demand in the summer high demand season. However, Utility B has the reverse scenario. Both utilities meet each other's needs for a quantum of power without any financial transactions with each other in their deficit power scenario. This is what we call "energy banking." It is similar to the barter system, wherein commodity transactions happen without currency payment. In energy banking, the exchange of the same commodity, i.e., energy, happens at different timelines of the year.

The flowchart depicting the methodology adopted by the authors for carrying out the research is depicted in Figure 1.

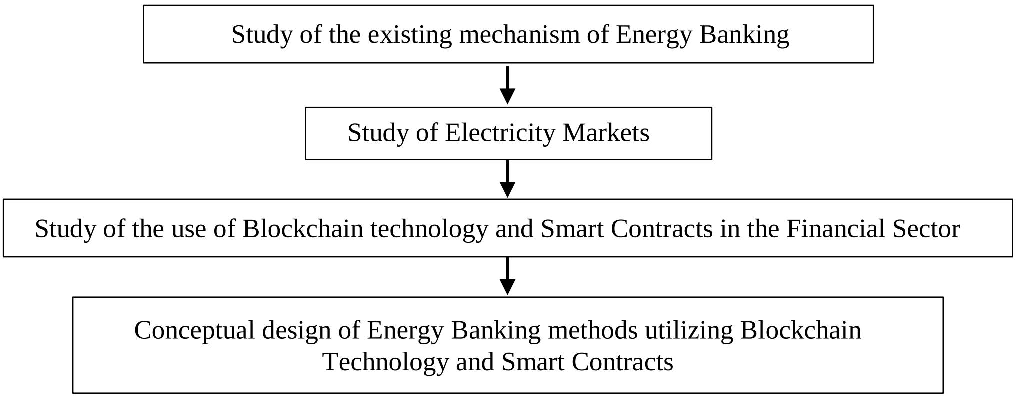

Figure 1. Flowchart showing the research methodology

The banking arrangement between two utilities on mutual consent basis in a simpler way is shown in Figure 2 above. In this arrangement, Utility-A is exporting the surplus power in its lean demand season to utility –B in the first cycle and importing the surplus power from Utility-B during its deficit power season in reverse cycle.

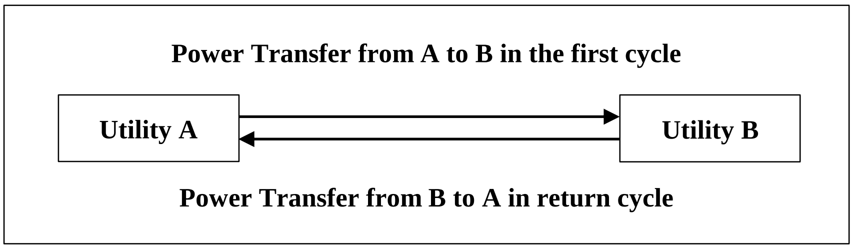

Figure 2. Concept of Energy Banking between two Utilities

The actual scenario of energy exchange between two parties is distributed for a longer period as shown in Tables 1 and 2 (data obtained from one of the Indian utility's bidding documents). This is an example of Energy banking through the process of competitive bidding.

Table 1. Supply of power by utility A to Utility B

Period	Option A		Option B	
01.05.19 - 30.09.19	Day Duration (Hrs.)	Quantum (MW)	Duration (Hrs.)	Quantum (MW)
	00:00 - 03:00 & 12:00 - 24:00	Return % to be specified	RTC (Round the Clock)	Return % to be specified

Table 2. Return cycle of power from Utility B to Utility A

Period	Option A		Option B	
01.10.18 - 31.12.18	Duration (Hrs.)	Quantum (MW)	Duration (Hrs.)	Quantum (MW)
	00:00 - 06:00 & 22:00 - 24:00	Up to 200	RTC (Round the Clock)	Up to 200

As seen from the above tables, Energy banking seems an easier way of exchange of electricity between two parties as there are no financial transactions involved. However, the actual scenario is entirely different. Despite having few advantages and ease of execution, Energy banking poses lot many challenges as outlined hereunder:

(i) Since these agreements are spanned for a longer time frame i.e. one party delivers power in the 1st quarter and is liable to receive power in the 3rd quarter, there are always chances of fall out of the contract due to political or any other issues which may occur in these time differences. This may incur a heavy loss to the party who has supplied power in 1st qtr.

(ii) The power exchanged among the parties occurs at different times of the day and different quarters of the year. The price of electricity is volatile and depends on real-time market conditions and corridor congestions. Since the power exchange takes place in different timelines, the cost of power will not be the same; hence one of the parties in the agreement is at a loss which may result in auditing problems at later stages.

(iii) Involvement of many stakeholders viz. respective Load Dispatch Centers for scheduling, Power Committees for energy accounting, traders, stakeholders, etc. Hence, there are chances of failure of the Energy banking agreement due to procedural lapses.

(iv) As explained earlier, some parties execute energy banking via tendering process, which itself is time consuming & also involves financial transactions in terms of Earnest Money Deposit (EMD), Bank Guarantee (BG), etc. In addition to this, open access charges up-to delivery points i.e. application fees & Operating Charges of Load dispatcher, Grid Connection charges, injection/drawl charges, Transmission Utility Charges, trading margin, etc. These transactions need to be ensured, monitored, and settled. Thus, an entire finance mechanism needs to be put in place and that's a cumbersome and time taking process.

(v) Once the agreement is executed, the parties become dependent on each other irrespective of knowing the actual demand, corridor availability, market price, etc. If there is any corridor failure or breach of generation contracts, the second party is left with no other option except to purchase power at market-determined prices which obviously will be higher. This inadvertent hike in the price of power is not covered in any contracts, only a minimal penalty clause is available. In the above-mentioned contract also, there exists a clause for the unsupplied quantum of energy at the end of the banking cycle. This clause allows the second party to settle @ mutually agreed price to the first party which is again an assumed price.

From the above points, it is clear that the Energy banking agreement requires a lot of human intervention at various stages. It is a time-consuming process & there is always a possibility of second party defaulting while returning power as there is a gap of approximately 3 months for the return cycle. Although the defaulting party is liable to pay a penalty on account of default as per contract, this penalty is not enough for the first party to arrange the same quantum of power from another source at a reasonable price. The same quantum of Electricity has different price tags at different timelines of the year; hence these agreements cannot be executed on a price parity mechanism. Since it involves public money at large, these agreements must follow sound commercial principles.

To mitigate the above complexities, crypto tokens & smart contracts [2, 3] based on blockchain technology [4] may be used for Energy Banking.

2. Use of Blockchain Technology in Energy Banking

The sample distributed network in which all the stakeholders involved in Energy banking i.e. designated accounting authority, Load dispatchers, Captive power producers, Distribution Licenses, Power Exchanges, traders, etc. is as shown in Figure 2. This proposed distributed network is a permissioned network. The parties which are not registered in the network cannot access any information. The transactions will be in encrypted form and can only be decrypted by the concerned parties only. All transactions will be completed through smart contracts and saved in the distributed ledger. Here, transactions do not limit to financial transactions only. It could be any document & data also.

To maintain the secrecy of documents, the same will be encrypted first and then put into the blockchain, so that same can be decoded only by concerned users in the network. For financial transactions, a Crypto-token, named iPowercoin is proposed to be issued by TIU (Token Issuing Utility). Designated accounting authority or any other authority approved by the regulatory commission may be designated as TIU. The initial value of iPowercoins will be equivalent to the product of MWH and the yearly average MCP (Market Clearing price) [5, 6] of Energy exchange for the last financial year. The proposed formula for one **iPowercoin** is as below:

Initial Value of one iPowercoin = *1 MWH*Yearly average MCP of Energy exchange for last financial year in INR (Indian National Rupee)* **(1 INR = 0.014 USD)**

Initially, both parties having an Energy banking arrangement will be required to deposit the amount equivalent to the product of contracted power (in MWh) and last financial year's average MCP of Energy exchange. If the Energy banking contract is for 200 MW, 8 hours, and 3 months @ yearly average MCP being INR 5 per KWH, then both parties have to deposit INR 200×1000×8×3×5×30 = INR 24,00,00,000 (approx. 32 lakhs USD) with TIU as initial deposit/guarantee money. TIU will issue 2.4 Lakhs iPowercoins for each party. These iPowercoins will be credited to accounts of both parties, but they can't be utilized without validation by TIU. The settlement will be done by TIU based on actual energy transacted @ market (Exchange) discovered price between both parties on daily basis. However, iPowercoins available with one entity can either be used in a single banking agreement or multiple banking agreements. If regulatory authority permits, then these iPowercoins can be used pan India for energy exchange or settling of any dues of the power market.

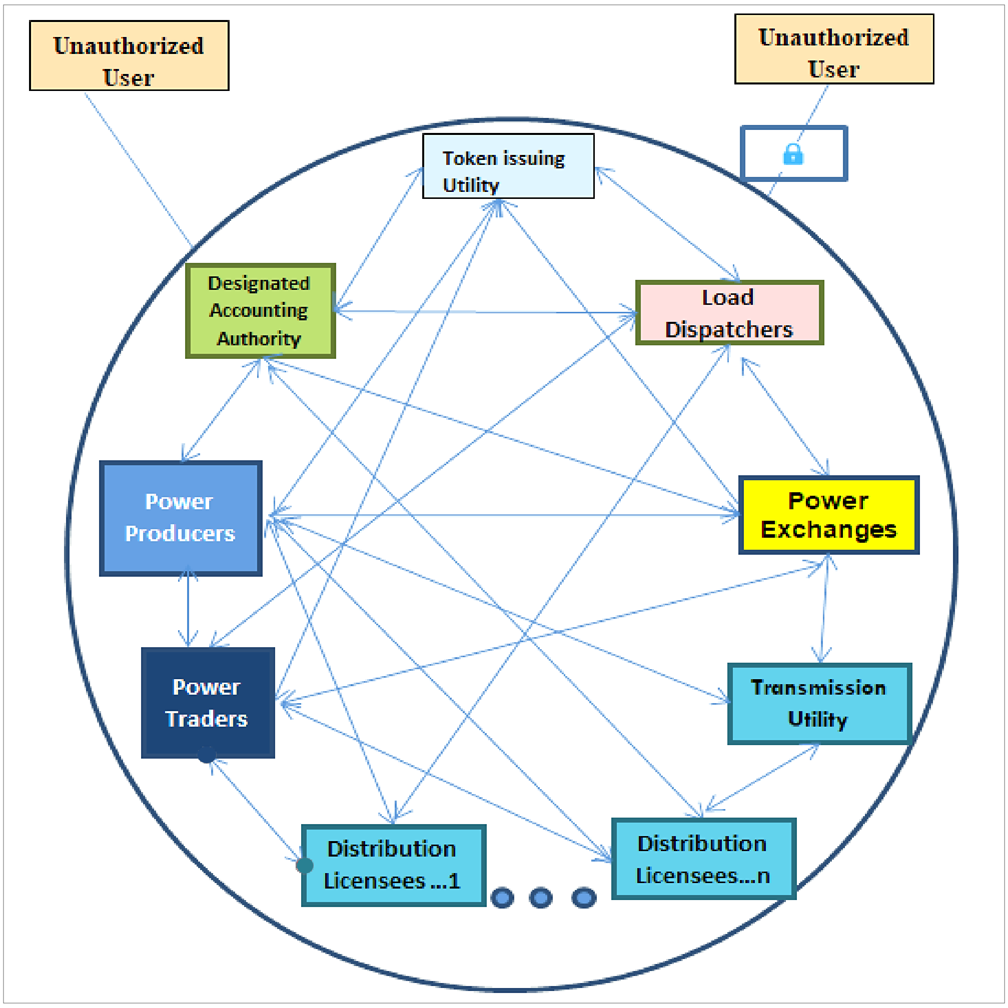

Figure 2. Distributed Network of Stakeholders participating in Energy Banking

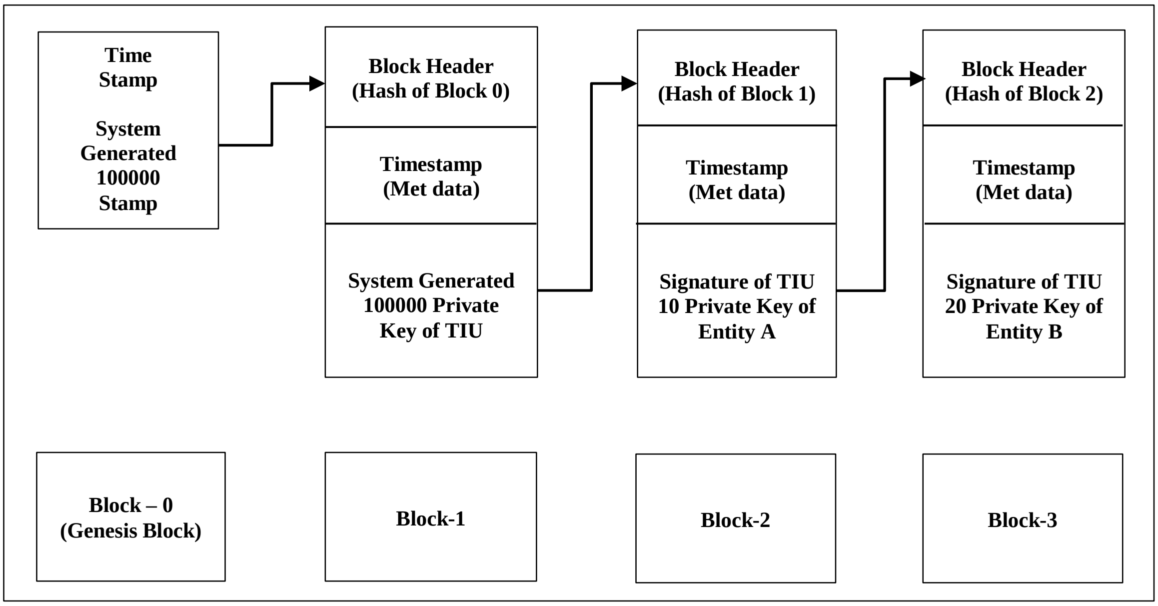

Figure 3. Blockchain Diagram for Time-stamped and Encrypted data

3. Proposed Method of iPowercoin Generation

As shown in Figure 3 the system-generated iPowercoins are saved in Block-0, known as Genesis Block [7]. The Genesis Block is the first block of blockchain generated by the system.

The first transaction in the blockchain is saved in Block-1 and is executed by the smart contract algorithm. The block header of block-1 is hash (SHA256 or SHA 512) of all the data available in block 0 as shown by the hash pointer [8]. Similarly, the block header of block2 has the hash of the entire block-1. The same process is repeated in all subsequent blocks entered in the blockchain. The entire block-chain is accessible to all the entities connected to the network. If any malicious entity desires to change any transaction/data in the block, the entire subsequent blocks need to be changed as every succeeding block has the previous block hash. Additionally, the malicious entity is required to change these transitions/data simultaneously on all the nodes connected in the network. This is practically very difficult which makes these transactions tamper-evident.

4. Proposed Bidding Process Utilizing Smart Contracts

The bidding process can be simplified by the use of Smart contracts and block-chain technology as shown in Figure 4. From the above figure, it is understood that all the processes during the bidding can be completed by smart contract transparently and securely with minimal human intervention.

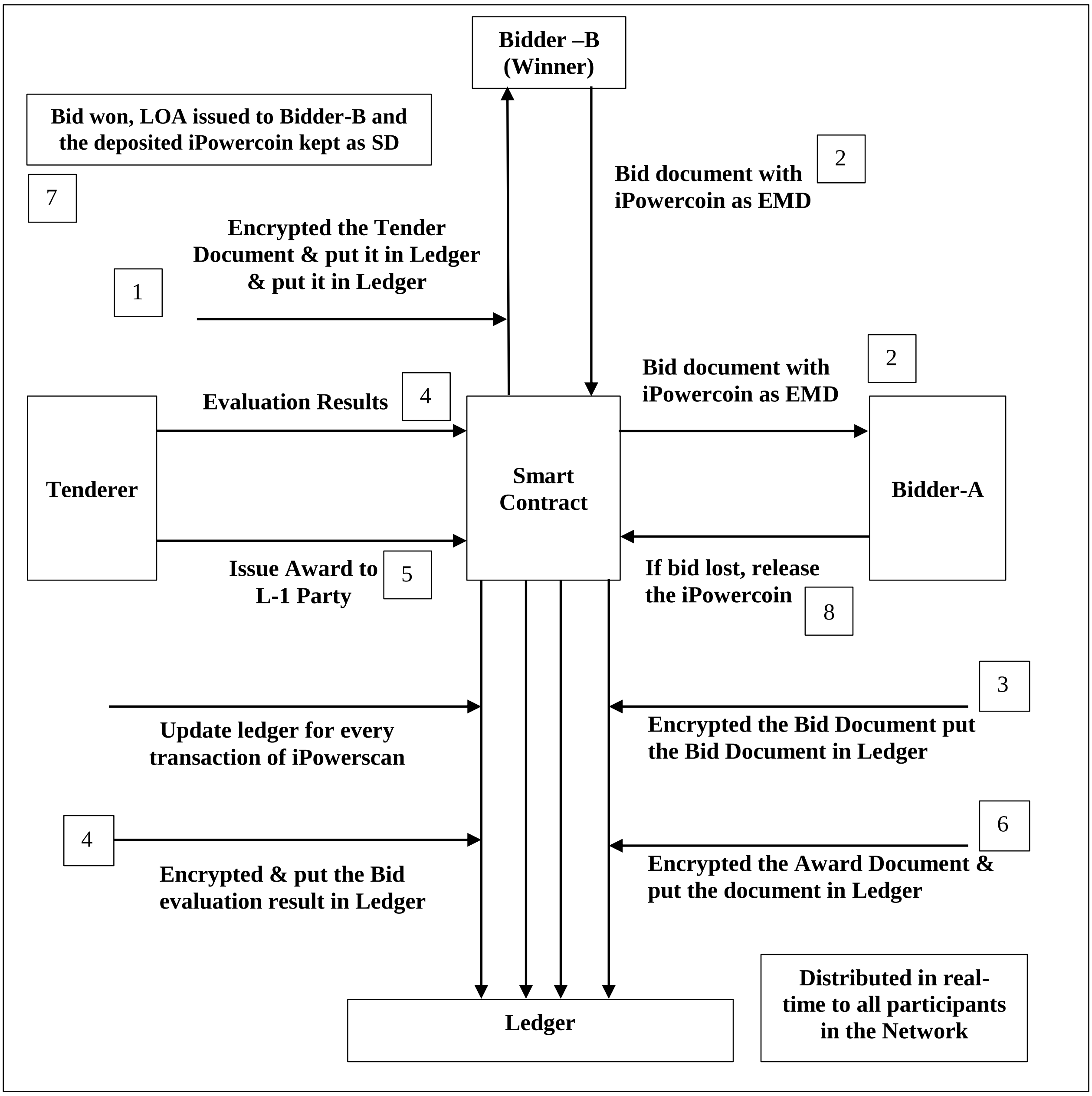

Figure 4. Proposed bidding process utilizing Smart Contracts and Blockchain technology

All the bid documents are made available on the network and could be accessed by all participants registered on the network. This will avoid the physical bid, which requires scrutiny & analysis of documents submitted by the bidder and there are chances of human error. Here, we are proposing that a certain quantity of iPowercoins are required to be deposited as EMD (Earnest Money Deposit) [9] by the bidders. These iPowercoins shall be kept as a Security Deposit (SD) [10] for the successful bidder and in case of an unsuccessful bidder, released as soon as the bidding process is completed. The bidder can utilize the same iPowercoins for any future contracts as well. This type of flexibility is possible only if we are resorting to smart contracts.

In the above process, the contracts are converted to computer code language, stored and replicated on the system, and supervised by the network of computers that run the blockchain. This would also result in ledger feedback such as transferring money and receiving the product or service. Energy banking is the best case suited for P2P modeling using smart contracts, DLT (Distributed Ledger Technology) [11-13], and blockchain technology. To resolve the challenges of Energy banking, there is a dire need to ensure that transactions happen smoothly, monitored, and settled amicably. To smoothen the financial settlement process and carry out Energy banking with price tag (different due to different timelines of the contract), use of block-chain with iPowercoins and settlement through smart contract is proposed.

5. Proposed Model of Energy Banking

After completion of the bidding process, the smart contracts will be put to real operation on the bidding platform as shown in Figure 5.

This model will calculate the amount of energy exchanged and its real-time price based on the inputs received from the inputs from accounts statement generating authority, Load dispatcher (Scheduling part), and Energy exchange (Real-time price of Energy). Based on the transactions on a day, the token stacked with designated authority will be released and deposited to the beneficiary's account. Also, the open-access charges i.e. Load dispatcher's application fees & Operating Charges, Grid injection/drawl charges, Transmission Utility Charges, trading margin, etc. can also be transferred in form of iPowercoins (if these coins are given the mandate by the regulatory body for use in a predefined territory) to the respective beneficiary. Smart contracts will have all the predefined terms and conditions of all transactions of all involved parties. All the data received from different entities, the transaction of iPowercoins, and settlement of accounts will be stored in the blockchain and can be accessed (Read-only) by all registered/involved parties and auditors (with an exceptional registry key [14-16] valid for auditing period only).

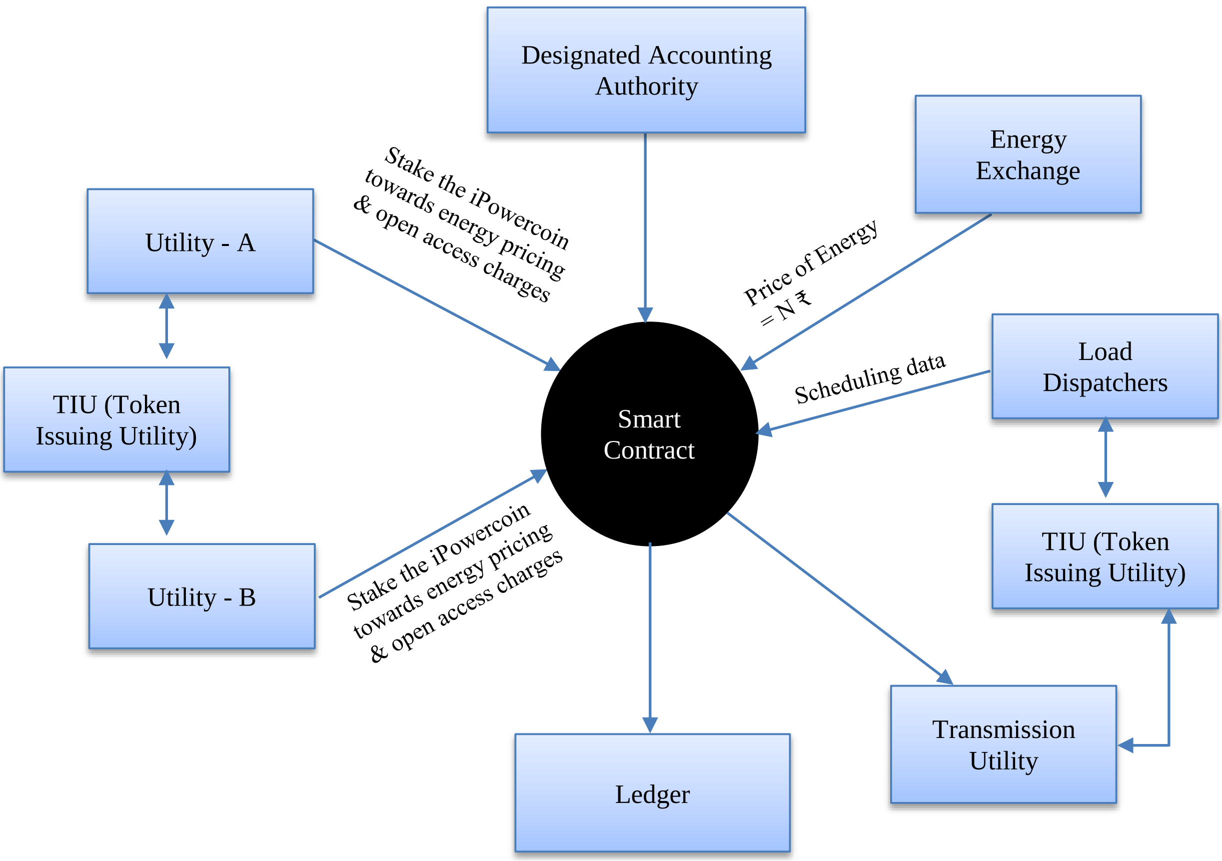

Figure 5. Block diagram for the proposed model of Energy Banking

6. Way Forward

As of now, there are no specific regulations regarding cryptocurrency in India or many countries that may act as a deterrent to the implementation of the proposed model. Since the proposed model doesn't suggest trading of crypto tokens, i.e. iPowercoins, and it's only a P2P model, it may be accorded approval by the respective authorities.

Regulatory authorities are already in the process of redesigning the electricity markets across the globe and the said model of energy banking may also be proposed to be incorporated into it for future regulations. This will aid in the use of decentralized ledgers, smart contracts, and ensure hassle-free transactions with a fair value of electricity at different times. The author of this article strongly believes that no transaction of energy can occur at a fixed price, but rather its price changes every second. Hence, all energy banking transactions need to be tagged with a real-time price using the latest technology with minimal human intervention. The future of electricity markets lies in the adoption of the latest technology, and this model may act as a catalyst to develop it at a faster pace.

7. Conclusion

Energy banking is synonymous with barter systems, and blockchain is a window to the future. Whenever east meets west or tradition meets technology, it's a scintillating experience, and similar will be the fusion of energy banking and block-chain. The proposed model of energy banking encrypted with blockchain technology will pave the way for future smart contracts and carry out energy banking transactions in a more reliable, secure, and assured manner. The major advantages of this method are digitally encrypted records, a minimum human interface, easy financial transactions, no dependability on a single party, and accessibility to global markets. Small steps get converted into giant steps with time. The same is being envisaged by the authors as the introduction of blockchain in energy banking may pave the way for the development of full-fledged future electricity markets in India and other countries as well.

8. Declarations

8.1. Author Contributions

All authors have equally contributed towards Conceptualization, methodology, formal analysis, investigation, resources, writing—original draft preparation, writing—review and editing, visualization. All authors have read and agreed to the published version of the manuscript.

8.2. Data Availability Statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

8.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8.4. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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