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Blockchain Application In Management Of Electricity Data

Thi Ngoc Thuong Huynh[1*], Trieu Tan Phung[2], Ngoc Au Nguyen[1], Trong Nghia Le[1], Duy Luan Huynh[1], Phuong Nam Nguyen[1]

[1]*Department of Electrical and Electronics Engineering, HCMC University of Technology and Education, Vietnam*
[2]*Department of Electrical and Electronics Engineering, Cao Thang Technical College, Ho Chi Minh city, Vietnam*

[*] Corresponding author. *Email: thuonghtn@hcmute.edu.vn*

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ABSTRACT

This paper presents a model of using smart electronic meters and network tools to store information about power, price, and customer code in information blocks of Blockchain applications to manage electricity bills. Price transactions will be stored as a data block. The following data block will be linked to the previous, eliminating third-party management. The web user interface is designed to allow customers and administrators to monitor and receive notifications of suspected data attacks. The web application is developed by using Visual Studio software, which supports the C# language, popular among programmers and web developers. The data obtained from the meter is stored using Microsoft SQL Server, a powerful and popular database management system widely used in web applications to improve database services and reduce problems encountered in application development. Experimental model on the EPM5500P meter offers high stability, transparent and secure data management, which can be applied to a large scale such as buildings or industrial areas.

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1. Introduction

Blockchain technology has the potential to greatly benefit the electricity industry by increasing transparency, efficiency, and security in all areas of the power system. For example, Blockchain can be used to create a distributed and transparent profile of transactions in the energy market, making electricity transactions between producers and consumers more efficient and secure [1], [2]. This leads to increased competition, lower costs and better price determination in the energy market.

There is increasing interest in the application of Blockchain technology in the power system, especially in the field of energy management and trading. In recent years, a few articles have mentioned this issue such as: In [3], the paper provided valuable insights into the potential of blockchain technology in the energy sector, while highlighting security challenges and recommendations to address them. In [4], the potential benefits of using blockchain in the electrical industry are discussed, such as growth in transparency, better efficiency, and enhanced security. They also added on blockchain's applications, including distributed energy resource management, energy trading between partners, network planning and management, and energy certificate trading. In addition, the author also highlighted some of the challenges associated with blockchain implementation in the electricity field, such as the high computing power required for blockchain operations and the need for a standard platform for data sharing. Also, they mentioned the need for precise regulation and standardization for blockchain-based systems, which will ensure safe and reliable operation in the electricity sector. In [5], the author had performed a systematic textual overview of the existing texts on the topic and analyzed the features of blockchain technology, including history, structure, types, and applications. Besides, the article discussed the challenges and opportunities involved in implementing blockchain technology in various fields and highlighted some of the existing solutions to these challenges.

The application of Blockchain in the electricity industry is still in the early stages, it is necessary to research and evaluate the possibility and impact of the application of Blockchain in the electricity

industry, including assessing the technical and economic impact of blockchain implementation in practice, as well as reviewing policy and regulatory challenges.

The article presents a model using Blockchain in electricity bill data management. The rest of this paper is organized as follows. The basic concepts of Blockchain application in data management are presented in Sections 2 and 3. The idea of building a model for collecting and managing data from smart meters linked to google apps, Microsoft SQL and Visual Studio is formulated in Section 4. From there, create a database to store, manage and build a web user interface.

2. Blockchain introduction

Blockchain is a distributed digital that records transactions securely and transparently, using cryptography to ensure data integrity and privacy. One of the most well-known applications of blockchain is in cryptocurrency. Furthermore, it has other potential uses in areas such as supply chain management, voting systems, and decentralized finance, etc. Each Block in a string usually consists of two elements: header and data.

- Header: Contains the hash value and the collated hash code
- Data section: Contains the main information that you want to store such as transaction history information, diplomas, certificates, electricity indicators, etc. Data is called transactions.

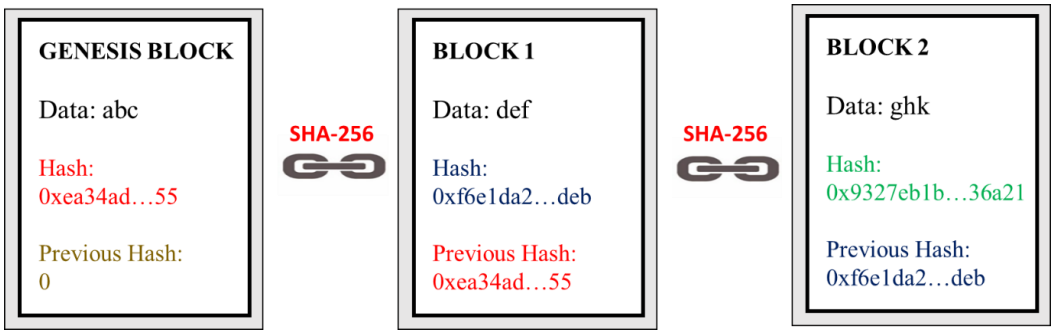

Figure 1. *Structure model – data link of Blockchain* [6]

The structure of a block chain is presented in Figure 1 based on the document [6]. The blocks are connected together by a collation hash code, the first block has a collation hash code of 0, the second block uses that collation hash code with the hash of the first block, so linked together into one block chain.

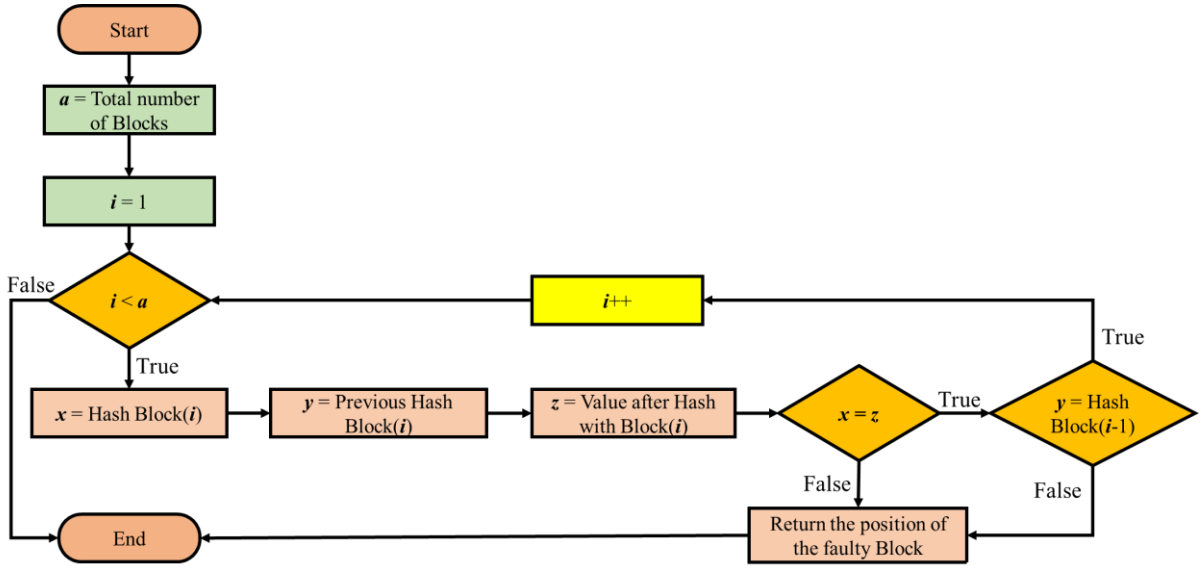

Figure 2. *The flowchart of Blockchain construction process*

Blockchain system is a combination of 3 main technological mechanisms:

- Cryptography: Hash function.
- Distributed network.
- Decentralized consensus.

The flowchart of creating chains of blocks in the Blockchain structure is shown as Figure 2. Figure 2 illustrates the process of verifying information of the blocks in the blockchain model. This is to ensure the safety and transparency of stored information. To check the integrity of the blockchain, the total number of blocks in the system is taken, then a variable ***i*** is run, which starts from Block number 1. If ***i*** is less than the total number of blocks, the Hash code of the current block will be compared with the value after re-calculating the Hash code of the current block. If the two values are the same, the PreviousHash of the current block will be equal to the Hash of the previous block, at this point the entire data has no issues, and the program will continue to run until the variable ***i*** is greater than the total number of blocks. Otherwise, it will return the position of the wrong block.

3. Application of Blockchain in data management of power systems

The application of Blockchain in monitoring customer electricity bills has scientific significance in the development of Blockchain technology in the electricity system and market. From there, this application can build and develop other apps such as payment for transactions in the electricity industry, combining Blockchain with IoT technology to build a stable, safe and transparent smart grid. Researchers J. Hong, J. Li, L. Zhang and colleagues discussed the potential benefits of using blockchain technology in the management of engineering projects in the power system fields. It explored how blockchain can improve transparency, efficiency, and security in project management and presented a case study to demonstrate the technology's practical application [7].

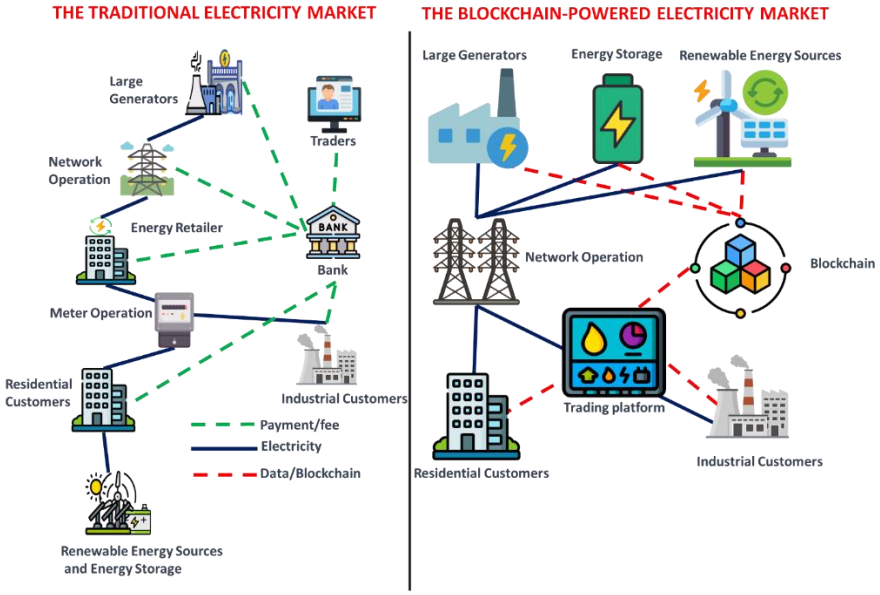

Figure 3. *The electricity market transformation with Blockchain* [8]

A representation of the new energy market structure utilizing blockchain technology is shown in Figure 3 based on [8]. Blockchain technology contributes to the grid's functionality in the control center through this structure. The blockchain will be a decentralized network that makes it easier to handle transactions quickly, securely, and transparently, which makes it different from the previous market structure.

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4. Application

The proposed model is built in the form of MVC (Model - View - Controller). Model is to use SQL Server to create the database. View is the display interface of the Website, where customers as well as administrators monitor recorded information. On the admin interface, they can receive error messages when there is abnormal intervention. Controller is the place to get data from two fields: get data from the Model and transfer it to the website, when the user performs an action on the Website, it transfers data back to the Controller and updates the new data to the Model. Controller is responsible for creating Block, setting Hash code, building integrity for blockchain. The block diagram below shows an overview of the relationship between the fields in Figure 4.

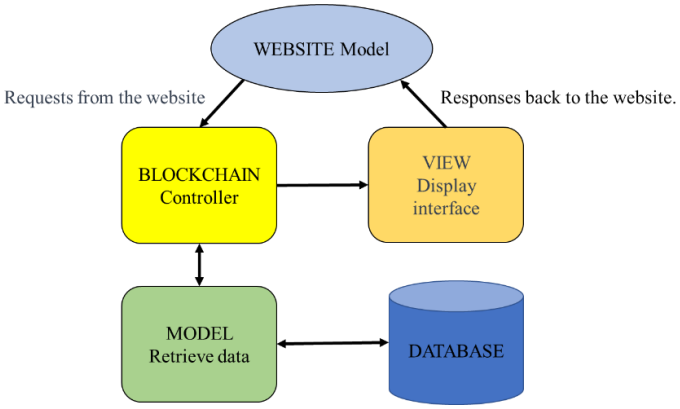

Figure 4. *The block diagram of MVC model*

From the block diagram illustrated in Figure 4, the working process of the model is presented in detail as shown in Figure 5 and Figure 6. The administrator is a decentralized network of computers that read parameters from power meters of customers. When the data is updated on the system, the computers in the system also simultaneously authenticate and store it in a separate server system. After being authenticated, the data will be hashed through the hash function and put into a block which then be concatenated into a chain with the previous blocks, forming a Blockchain that cannot be destroyed, deleted or edited. On the side of customers or administrators who need data for report analysis, it can be accessed through the output portal extracted from the Blockchain and the data storage server to look up information. The client can search by using the client code, hash code or possibly the identifier of the provided Block. The communication operations with the system are performed on the Web interface.

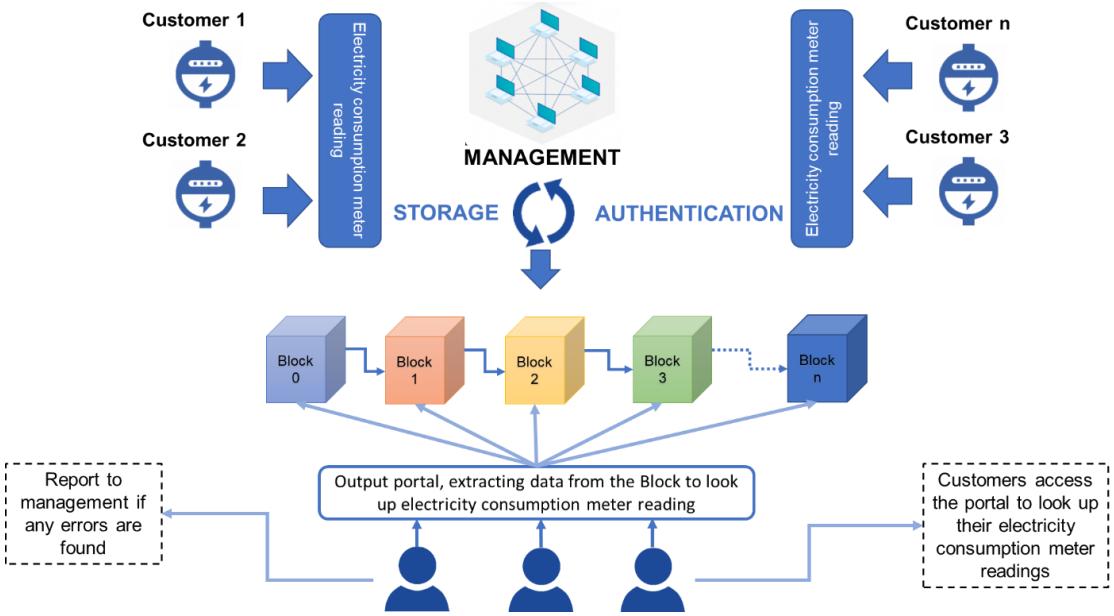

Figure 5. *Block diagram overviewing the process of collecting and managing data of the proposed model*

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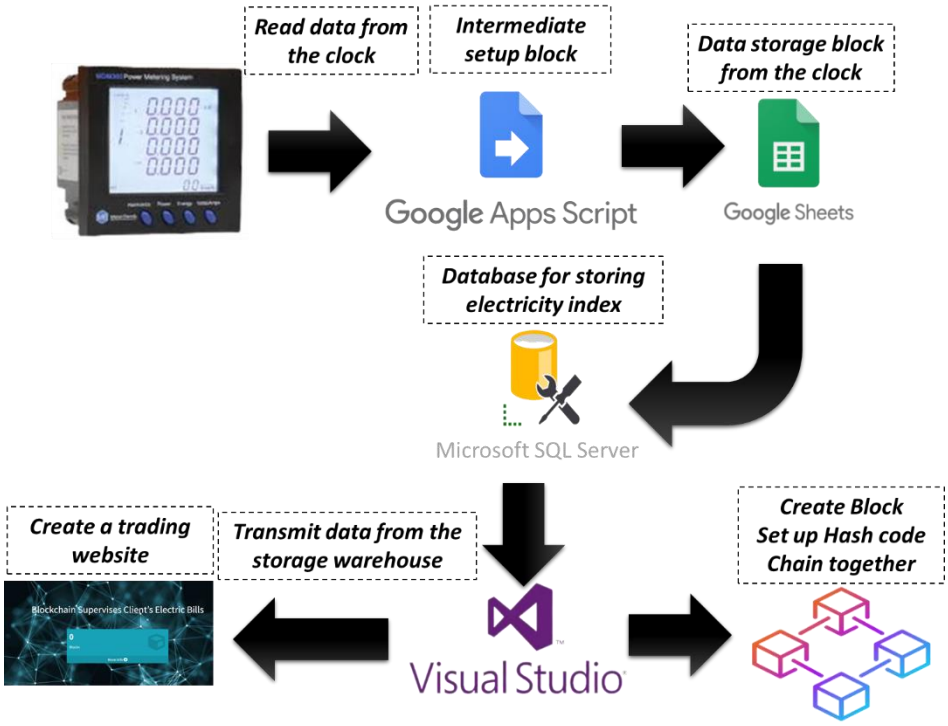

Figure 6. *Block diagram of the application of technologies in the model*

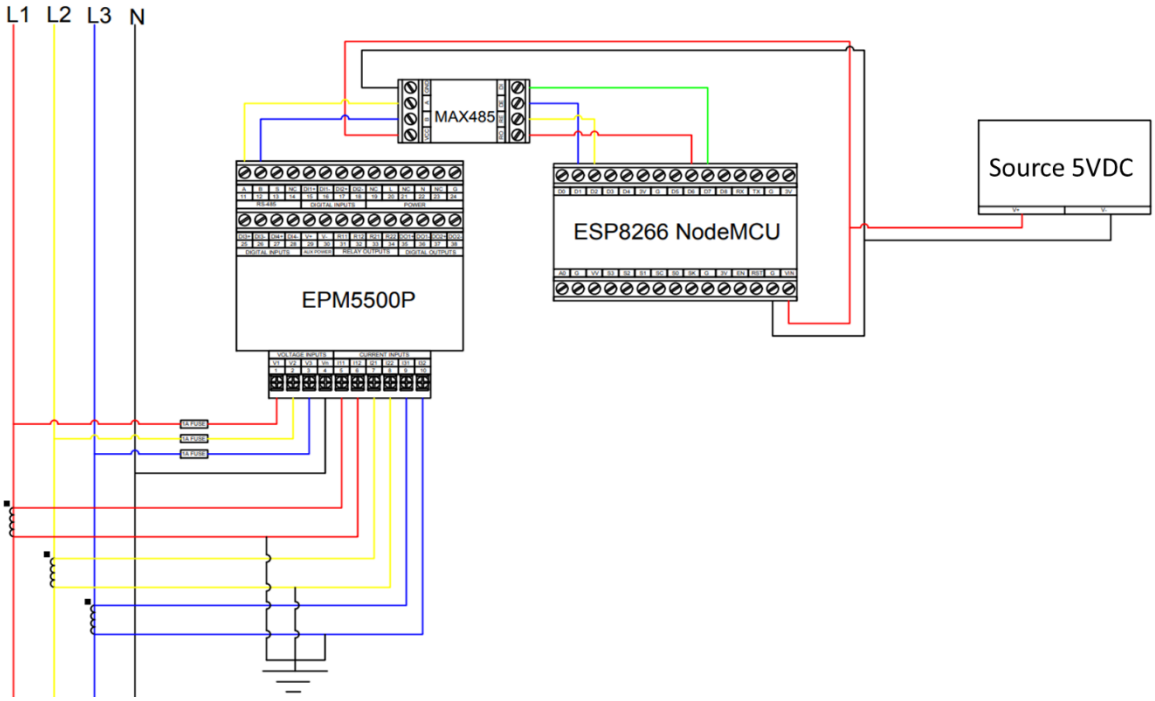

Figure 7. *Wiring diagram of the ESP8266 NodeMCU and Max485 hardware modules to EPM5500P*

In Figure 6, the meter parameters are read from the EPM5500P meter through the intermediate setup block and stored in Google Sheets. The hardware in the model needs an ESP8266 NodeMCU module and a MAX485 converter to convert RS232 signals to RS485 communication standard for faster and farther data transmission. Then, these stored data are saved in a database created by the Microsoft SQL Server Manager Studio application. According to the above data, using Microsoft Visual Studio tool is to create a Blockchain system and build a website to display the customers' electricity indicators. Besides, figure 7 shows the wiring diagram connection between the EPM5500P power metter and the electronic circuit: ESP8266 NodeMCU, MAX485. The data structure collected on Google Sheet is presented as shown in Figure 8. The data will be generated with a Hash code and form a block stored in the SQL data system. Algorithm flowchart in web building is shown in Figure 9.

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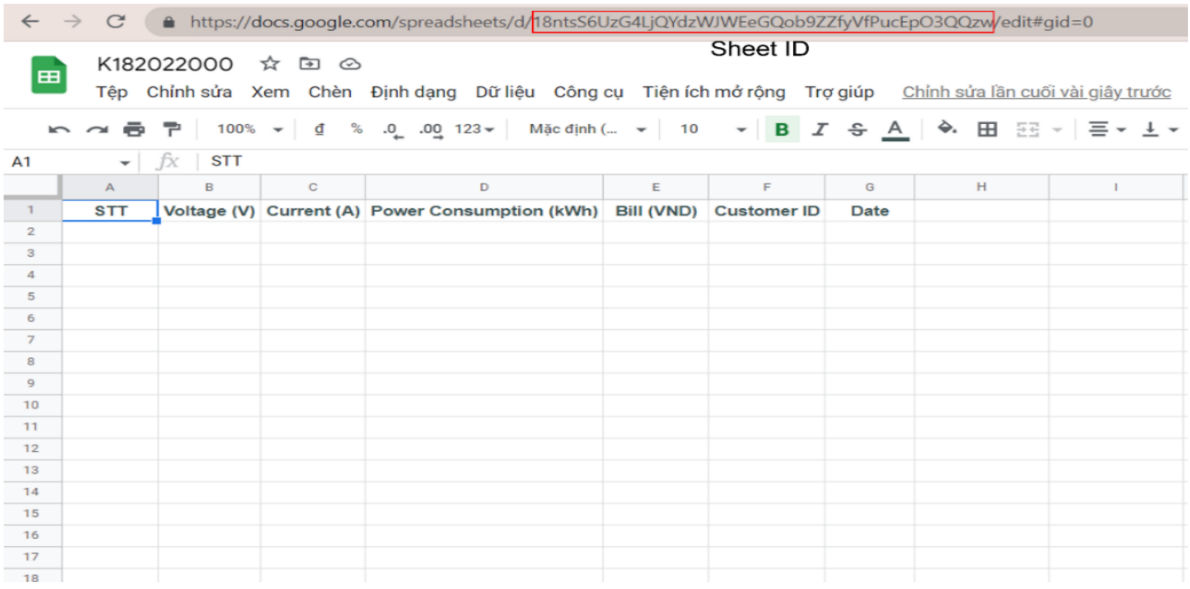

	Id	V	I	A	Bill	CustomerID	Date
1	7E111AFF-0957-4D84-8DC9-2D484819A40A	233	8	1269	3452563	k182022001	2022-06-26
2	7705F57C-BF00-4BF4-8BAF-33314AB4B4CA	229	6	1248	3391096	k182022000	2022-06-26
3	6BDE51B5-6C36-4FF5-8D76-A963397AA8E8	220	5	1200	3250600	k182022002	2022-06-26

Figure 8. *Data structure stored on Google Sheet and SQL database*

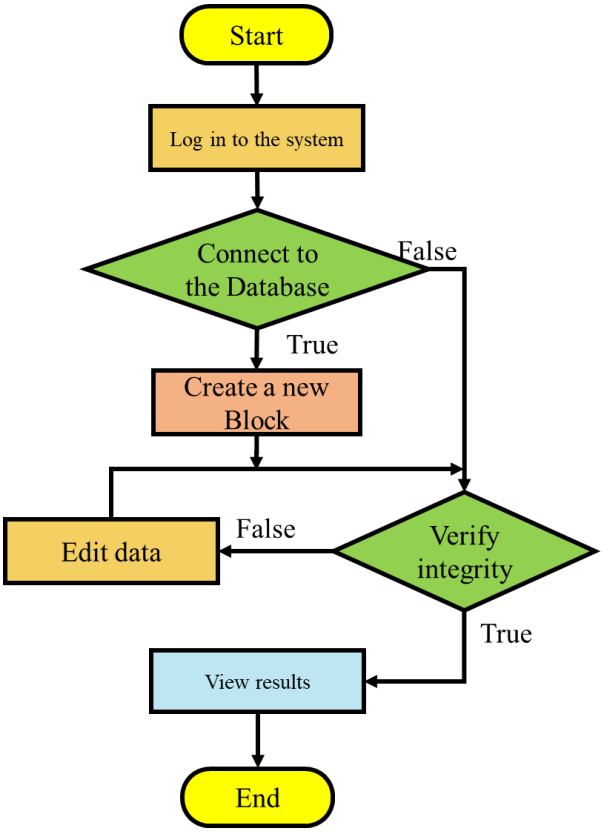

Figure 9. *Flowchart of software operation design*

The procedure of creating a data block and inserting it into the database is shown in Figure 9. First, To add Blocks containing information and data of customers, it is required to log in with administrative rights. At this time, the features of adding Blocks are acceptable thanks to the options of adding Blocks

connected to the database. After adding Blocks and checking the data integrity of the Blockchain in the system, if correct, make sure the data is good, otherwise edit the data, finally see the results of the blocks are generated in the Blockchain. If users are not logged in, they only have the right to view and look up the system's encrypted data information.

The strength of the application when making use of Blockchain technology is to detect changes in data, both the customer and the management center can see the error, know which block, information or customer is being changed. When detected, customers can report to the management center in order to promptly handle it through the data recovery function of Blockchain, which creates transparency, integrity and decentralization in the network, ensuring that all networks in the management center and customers can see if the chain operation is going wrong.

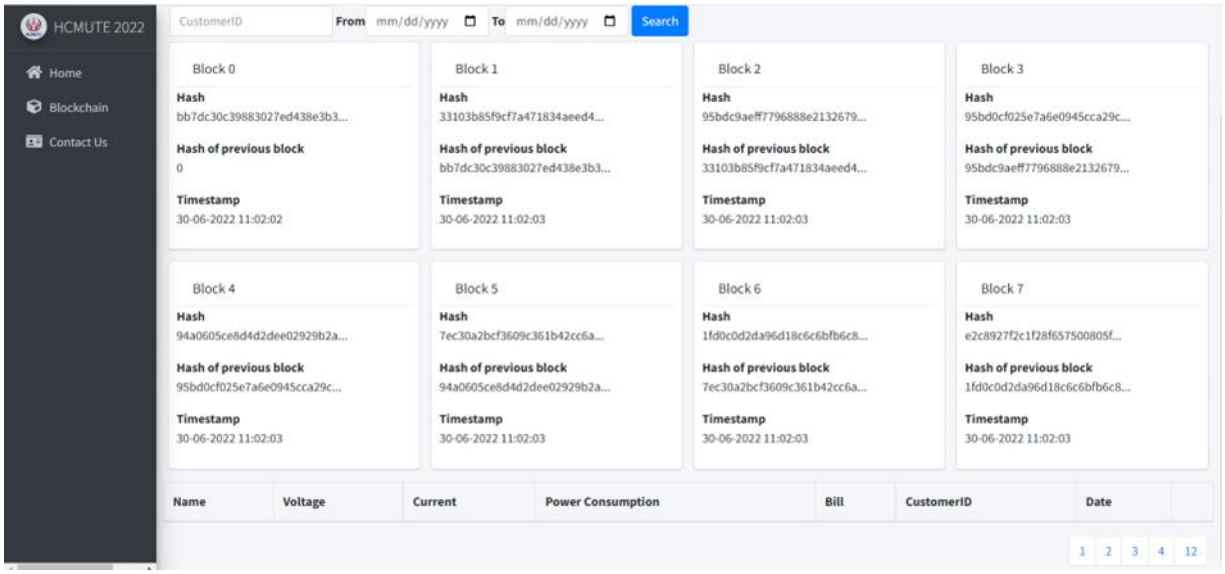

Figure 10. *User interface on website to monitor electricity price*

5. Conclusions

The article presents the application of Blockchain technology in managing electricity payment information. In addition, the article also presents the design of a practical model that applies the proposed method, including hardware and software components. In the process of data collection and testing, the model shows the applicability with the system scale. The model is highly stable, can recognize anomalies and report errors to the system. In addition, the web interface is designed to be clear and easy to use. The topic can be a reference for other applications in the management of electricity parameters, or macro applications in the power system.

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REFERENCES

[1] S. Johanning and T. Bruckner, "Blockchain-based Peer-to-Peer Energy Trade: A Critical Review of Disruptive Potential," in *2019 16th International Conference on the European Energy Market (EEM)*, Ljubljana, Slovenia, 2019, pp. 1-8, doi: 10.1109/EEM.2019.8916268.

[2] S. Suthar and N. M. Pindoriya, "Blockchain and Smart Contract based Decentralized Energy Trading Platform," in *2020 21st National Power Systems Conference (NPSC)*, Gandhinagar, India, 2020, pp. 1-5, doi: 10.1109/NPSC49263.2020.9331883.

[3] M. K. Hasan, A. Alkhalifah, S. Islam, N. B. Babiker, and A. K. Habib, "Blockchain technology on Smart Grid, energy trading, and Big Data: Security issues, challenges, and recommendations," *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1–26, 2022, doi: 10.1155/2022/9065768.

[4] I. Tonev and N. Nikolaev, "Review on Blockchain Applications for Electric Power Systems," in *2020 21st International Symposium on Electrical Apparatus & Technologies (SIELA)*, Bourgas, Bulgaria, 2020, pp. 1-4, doi: 10.1109/SIELA49118.2020.9167057.

[5] H. R. Andrian, N. B. Kurniawan and Suhardi, "Blockchain Technology and Implementation: A Systematic Literature Review," in *2018 International Conference on Information Technology Systems and Innovation (ICITSI)*, Bandung, Indonesia, 2018, pp. 370-374, doi: 10.1109/ICITSI.2018.8695939.

[6] Z. Wang, T. Wang, H. Hu, J. Gong, X. Ren, and Q. Xiao, "Blockchain-based framework for improving supply chain traceability and information sharing in precast construction," *Automation in Construction*, vol. 111, p. 103063, 2020, doi: 10.1016/j.autcon.2019.103063.

[7] J. Hong, J. Li, L. Zhang, X. Huang, X. Tu and Y. Liu, "The Application of Blockchain for the Management of Engineering Projects in Power System," in *2020 IEEE Sustainable Power and Energy Conference (iSPEC)*, Chengdu, China, 2020, doi: 10.1109/iSPEC50848.2020.9351075.

[8] M. Andoni, V. Robu, D. Flynn, S. Abram, and D. Geach, "Blockchain technology in the Energy Sector: A systematic review of challenges and opportunities," *Renewable and Sustainable Energy Reviews*, vol. 100, pp. 143–174, 2019, doi: 10.1016/j.rser.2018.10.014.

Huynh Thi Ngoc Thuong. received her M.Sc. degree in electrical engineering from Ho Chi Minh City University of Technology, Vietnam, in 2003. Currently, she is a lecturer in the Faculty Electrical and Electronics Engineering, HCMUTE. Her main areas of research interests are distribution network, electric drive and microgrid. She can be contacted at email: thuonghtn@hcmute.edu.vn

Phung Trieu Tan received his M.Sc. degree in electrical engineering from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam, in 2020. Currently, he is a lecturer in the Faculty Electrical and Electronics Engineering, Cao Thang Technical College. His main areas of research interests are Artificial Neural network, load shedding in power systems. He can be contacted at email: phungtrieutan@caothang.edu.vn

Nguyen Ngoc Au. received his Ph.D degree in electrical engineering from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam, in 2019. He is currently a lecturer in the Department of Fundamentals of Electrical Engineering. He is doing research in the areas of power systems, data processing and load shedding. He can be contacted at email: ngocau@hcmute.edu.vn

Le Trong Nghia. received his Ph.D degree in electrical engineering from Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam, in 2020. Currently, he is a lecturer in the Faculty Electrical and Electronics Engineering, HCMUTE. His main areas of research interests are load shedding in power systems, power systems stability and distribution network. He can be contacted at email: trongnghia@hcmute.edu.vn

Huynh Duy Luan graduated and received his Bachelor degree in Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam, in 2022. Currently, he is working in the field of ME to construct electrical systems in buildings. He can be contacted at email: 18142332@student.hcmute.edu.vn

Nguyen Phuong Nam graduated and received his Bachelor degree in Ho Chi Minh City University of Technology and Education (HCMUTE), Vietnam, in 2023. Currently, he is starting to pursue a Master's degree in Electrical Engineering at HCMUTE with a research focus on. He can be contacted at email: 18142046@student.hcmute.edu.vn