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키르기스 공화국 건물의 신뢰할 수 있는 에너지 인증을 위한 블록체인 개념의 구현

Implementation of the Blockchain Concept for Reliable Energy Certification of Buildings in the Kyrgyz Republic

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Abstract

The paper reviews the application of blockchain technology to enhance energy certification processes for buildings in the Kyrgyz Republic. It examines the existing challenges in achieving robust energy efficiency standards and reliable certification mechanisms. The research considers a solution involving blockchain integration through reviewing the current energy efficiency landscape and outlining a proposed quality control framework. Paper proposes a robust framework for issuing and verifying energy certifications inherent traits of transparency, security, and efficiency. This approach aims to strengthen quality control over energy certifications, promoting their integrity and fostering trust among stakeholders. It highlights blockchain's role in automating verification, ensuring data integrity, and facilitating stakeholder engagement. The research contributes to discourses on sustainable development by presenting a model to enhance building energy efficiency via innovative solutions.

키워드 : 주택에너지효율인증, 블록체인, 역사의 증명, 환경의 지속가능성, 기후변화
Keywords : Housing Energy efficiency certification, Blockchain, Proof of History, Environmental Sustainability, Climate Change

1. Introduction

Kyrgyz Republic is a mountainous country in Central Asia and highly vulnerable to the impacts of climate change. Recognizing the criticality of the situation, Kyrgyzstan actively seeks to combat climate change through several initiatives. The nation has pledged a commendable 44% reduction in greenhouse gas emissions by 2030. Additionally, capitalizing on its significant potential in renewable energy, particularly hydropower, the Government of Kyrgyzstan started investments heavily in this sector to diminish its dependence on fossil fuels and increase share of wind and solar energy to address climate change pressure. The overall goal is to reach 1,5 TWh renewable energy by 2030. These actions are important, as it is observed (Figure 1), both GDP and energy production have increased significantly over the past decade.

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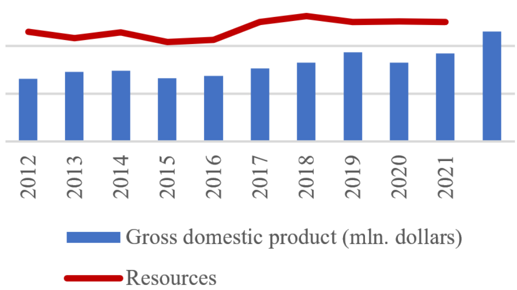

Figure 1. GDP and energy resources (source: National Statistics)

However, the rate of growth has not been the same. GDP has grown at a faster rate than energy production, resulting in a shortening gap between the two lines.

It is anticipated that energy consumption in buildings will increase considerably over the next several decades. In the absence of intervention, the overall final energy usage of buildings, along with the associated emissions, could rise to 60 – 90% above the 2005 levels by the year 2050 (D. Urge-Vorsatz, 2012, p. 5).

The data (Figure 2) after Logarithmic Mean Divisia Index (LMDI) (Ang, 2015) decomposition analysis suggests a complex interaction between economic growth, technological advancement, and environmental impact within the construction sector of the Kyrgyz Republic. Negative values throughout the period indicate improvements, suggesting a shift towards cleaner technologies and more efficient fuel use. However, diminishing negativity over time implies a potential slowdown in improvement rate.

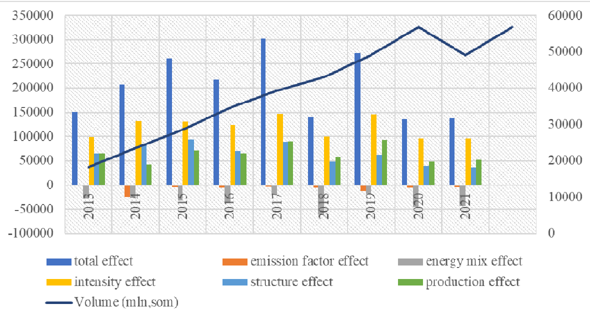

Figure 2. LMDI decomposition trends in ConstructionSector

The positive production effect confirms the expected link between increased construction activity and rising emissions. The fluctuations in magnitude suggest potential variations in project intensity or resource utilization over time.

While there are signs of progress, particularly in the adoption of cleaner energy sources and some improvements in energy efficiency in the construction sector of the Kyrgyz Republic, these have not been sufficient to offset the emissions impact of increased activity and structural changes within the sector.

The diminishing negative values in the emission factor and energy mix effects, along with the positive structure effect, suggest that there may be a need for more aggressive policies or technological innovations to continue reducing the carbon intensity of the sector. This could involve enhanced building regulations, incentives for green construction practices, adoption of sustainable materials, and continued investment in energy efficiency.

The construction industry holds significant promise for decreasing energy usage and CO2 emissions. Certification programs like Green Globes, LEED (Leadership in Energy and Environmental Design), and the Living Building Challenge encourage the sector to mitigate its substantial impact on climate change through strategies focused on energy conservation and reducing carbon emissions.

One of the main policy measures is to issue Energy Efficiency Certificates (EEC). Energy Certificates serve a dual purpose: they validate the claimed energy characteristics of new buildings and provide a basis for the operational efficiency of existing ones. For new constructions, certificates are issued to confirm compliance with energy efficiency criteria established during the design phase. For existing buildings, certificates are required during the processes of sale, rental, or leasing, as well as before and after major renovations. Voluntarily obtaining a certificate is also encouraged – it helps to regularly monitor the energy efficiency level of buildings.

The validity period of a certificate determines the frequency of its renewal and ensures the data's relevancy. The process of issuing a certificate is an integral part of the quality control system, as it clearly defines the steps necessary to obtain a high-quality and reliable energy certificate.

2. Blockchain and its benefits for Energy Certification

The process of issuing, renewing, and maintaining the quality of energy certificates is highlighted as crucial. This process plays a key role in assessing a building's energy properties from its initial design through to its use phase.

The duration for which a certificate remains valid establishes the update frequency, securing the relevance of its data. The certification process is a critical component of the quality assurance framework, marked by specific procedures that guarantee the attainment of a credible and superior energy certificate.

The measurement, reporting, and verification (MRV) framework plays an essential role in both the carbon credit marketplace and the assessment of building energy performance (BEP) for the energy certification (Singh, 2016, pp. 4-5). Despite its importance, the existing BEP MRV system falls short in providing a reliable resolution to existing challenges. Enhancing the reliability of this system can be achieved through the integration of Blockchain technology. Blockchain functions as a decentralized database, instantaneously accessible by all participants in the network. Once information is entered into a blockchain, it becomes permanent, distributable, and verifiable. These attributes of Blockchain technology contribute to making the MRV system more transparent, traceable, and cost-effective. Consequently, this technology holds significant promise for designing features of the Emissions Trading System (ETS) and for serving as an effective mechanism for carbon emissions (Sven, 2019).

A recent investigation into energy certification systems revealed the possibility of leveraging blockchain technology for the trading of Guarantee of Origin (GoO) certificates (Castellanos, 2017), also known as green certificates. Regulators issue these certificates to producers of renewable energy for each megawatt-hour (MWh) of verified renewable energy generated. The certificates detail the production time, location, method, and producer, as well as the ownership of the associated green assets. Although these certificates can be traded, sold, or retired, their transaction process is often complex. The findings from the paper suggest that using blockchain could authenticate green certificates, enhance the system's transparency, and lower transaction costs by eliminating the necessity for an intermediary regulator in managing the system.

3. Method

The paper proposes a conceptual framework for enhancing building energy efficiency via Proof of History (PoH) structured methodology. The framework outlines a system architecture where PoH is utilized to record, verify, and manage indicators in a transparent, immutable, real-time tracking and optimization of energy use.

A challenge in the cryptocurrency realm is node synchronization. The efficiency of this synchronization directly impacts the blockchain's capacity to handle transactions. Essentially, the quicker the synchronization, the higher the number of transactions the network can manage per second. Time-based synchronization, which is crucial for this process, requires the use of timestamps.

PoH concept allows for the creation of a decentralized and immutable ledger of events with a high degree of accuracy in terms of the order and timing of those events. This concept can be applied to the calculation of energy efficiency metrics for buildings, using timestamps to record energy consumption data and other relevant information.

The concept involves a comprehensive process starting with the creation of a data structure specifically designed for energy certificates. This structure aims to accurately represent the building's energy consumption and efficiency metrics, ensuring it aligns with the technological frameworks of PoH frame. To populate this data structure, energy usage data is collected from sensors and meters installed throughout the building.

Once the data is gathered, it undergoes a validation process to confirm its accuracy, which includes cross-referencing with historical records and adherence to industry standards. After validation, a PoH sequence is generated, embedding the verified energy data along with crucial metadata, such as timestamps and details identifying the building. This sequence, secured by the cryptographic properties of PoH like SHA-256, establishes a reliable record of events in their chronological order on the blockchain. With the PoH sequence established, energy certificates are issued on the blockchain, serving as a testament to the building's energy consumption levels and efficiency.

These certificates not only validate the building's performance but also act as a tool to promote energy efficiency among stakeholders, potentially unlocking incentives for further enhancements in energy conservation. To ensure ongoing efficiency and performance, the building's energy metrics are continuously monitored, allowing for the identification and execution of opportunities for improvement in energy usage and efficiency. This end-to-end process forms a dynamic and secure approach to managing and certifying building energy performance using the cutting-edge technologies of blockchain and PoH.

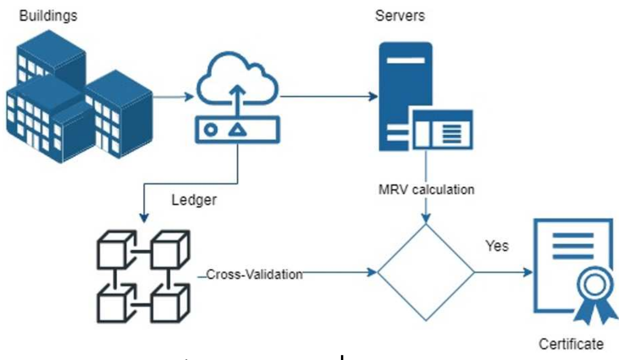

Figure 4. research process

3.1 Case example

In this scenario, the data contains energy data for a single building with the ID 12345. The data is collected daily, and includes the following columns: building_id (the unique identifier for the building); timestamp (the date and time that the energy data was collected); energy_consumption (total energy consumption of the building in kWh); energy_efficiency (energy efficiency of the building, represented as a ratio of energy consumed to energy produced); electricity_consumption (electricity consumption of the building in kWh); heating_consumption.

PoH enables to facilitate the network's continuous operation through automatic rotation without requiring validator intervention like in other blockchains. Furthermore, PoH enables to enhance the block creation time, replication, throughput, and data storage within the ledger.

building_id	timestamp	energy_consumption	energy_efficiency	electricity_consumption	heating_consumptic
12345	2023-01-01 10:00:00	1000	0.8	500	500
12345	2023-01-01 11:00:00	1100	0.75	550	550

Figure 4. Case example

4. Results

In our research, we proposed a conceptual framework to evaluate energy efficiency indicators for buildings by using the PoH concept to document energy usage. This approach was applied to gather energy consumption figures from a selection of both commercial and residential structures. To ascertain the data's precision and wholeness, we employed both statistical analysis and machine learning techniques.

These PoH sequences enabled to compute various energy efficiency indicators for the buildings, such as energy efficiency and energy use intensity. Furthermore, it can utilize smart contracts on the blockchain to store these energy efficiency metrics, thus establishing a decentralized and tamper-proof ledger of the energy performance for each building and issue the energy certification.

5. Discussions and conclusion

The results of this study demonstrate the potential of using PoH and timestamps for calculating energy efficiency metrics for buildings. By creating a tamper-proof record of energy consumption data and relevant metadata, we can improve the accuracy and reliability of energy efficiency metrics, which can help building owners and operators identify cost-effective ways to improve the energy performance of their properties.

However, there are also some challenges and limitations to consider when using PoH and blockchain technology for energy efficiency certification. For example, the accuracy and reliability of energy consumption data is dependent on the quality and maintenance of sensors and meters used to collect the data. Additionally, the use of blockchain technology requires a certain level of technical expertise, which may be a barrier for some building owners and operators.

Further research is needed to explore the potential of using PoH and blockchain technology for energy efficiency certification in different contexts and building types. For example, future studies could investigate the use of PoH and blockchain technology for certifying the energy performance of renewable energy systems, such as solar panels and wind turbines. Additionally, future studies could explore the potential of using machine learning algorithms and other advanced analytics techniques to improve the accuracy and reliability of energy efficiency metrics.

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