Smartlabel: a proposal for applying blockchain in the use of the PROCEL seal

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Abstract. Consumers need information to make decisions when they are buying a piece of new equipment. Logos, labels, and quality descriptions are necessary for this purpose. Therefore, energy efficiency labels aim to persuade consumers to buy more efficient products and manufacturers to produce them more efficiently. Labels and equipment tags also ensure traceability to help consumers reduce information asymmetry regarding product quality and increase confidence in purchasing the product. A technology that presents itself to fill this gap is blockchain, which can help address each aspect by enabling traceability, certification, verification, and security of the equipment's presented information. This study aims to propose a smart energy efficiency label (smart label) using blockchain technology for secure access, traceability, validation, and certification of all information related to the energy performance of the labelled equipment. The methodology of this work involves mapping the process for using the PROCEL label on a typical household appliance from the Brazilian Labelling Program (PBE), demonstrating the application of blockchain technology during the process. With the PROCEL label, the use of blockchain can inform the entire lifecycle history of that equipment and all the steps followed until it reaches the hands of the consumer. Thus, consumers can trace and verify the results of the tests the equipment has undergone, make comparisons between various products, understand the ecological impact of the development of that product, and have the assurance that the product containing the blockchain-enabled label is not counterfeit. The smart label has great potential for agility, transparency, security, interoperability, auditability, reliability, and product traceability.

1. Introduction

The quality of a product can often be presented through its label, tag, or seal. Research demonstrates that the product seal is an item that influences consumers' product choices. Similarly, traceability labels can increase consumers' purchase intentions [1].

Consumers require information to make decisions, and logos, labels, and quality descriptions provide information to help consumers differentiate products and manufacturers in terms of the delivered product quality [1]. A label is a sticker, which can be either compulsory or voluntary, affixed directly to products or packaging, containing important information. In the case of energy efficiency labels, they usually provide information about the energy consumption of the product. Thus, the objective of energy efficiency labels is to convince consumers to buy more efficient products and manufacturers to produce

them more efficiently as well [2]. Labels are help educate consumers and can contribute to further savings.

These labels allow for the comparison of energy efficiency among similar products. However, they will only be effective in assisting consumers in choosing a quality and more energy-efficient products if there is a variety of similar and labelled products available in the market [2].

Energy labelling programs are a reality in most countries worldwide and are a key element of energy efficiency policies [3]. As investments in energy efficiency often have a high return rate, energy efficiency labelling campaigns can influence consumer behaviour and lead to greater competitiveness of energy-efficient products in the market [4].

Compulsory energy efficiency standards are generally the most effective way to rapidly improve the energy efficiency of equipment. In contrast, voluntary energy efficiency standards provide an alternative option to encourage energy efficiency programs [2]. Several steps must be followed to establish energy efficiency standards and labels. According to [2], it is necessary to establish testing procedures, standards, labels, and incentive programs.

Energy efficiency standards aim to determine the minimum energy performance of something, often prohibiting construction or sales when minimum levels are not met. This encourages manufacturers to invest in more efficient product development and construction, reducing overall energy consumption or investment to meet this demand [2]. Regarding to [2], it is essential for the standards that establish minimum energy efficiency levels to be regularly updated and try to keep up with trends in more developed countries, to compel manufacturers to upgrade and develop more energy-efficient products.

In addition to providing information about the energy efficiency of the equipment and labels, while attempting to inform about a product's provenance, such as origin, authenticity, integrity, and custody, also assists consumers in their decisions. Equipment labels and tags that ensure traceability help consumers reduce information asymmetry regarding product quality and increase confidence in the product they are purchasing. One technology that addresses this gap is blockchain, which can aid in establishing each aspect by enabling traceability, certification, verification, and security of the equipment's presented information. This transparency can help consumers better assess the qualities of a specific product [1, 5].

The immutability of the blockchain and shared access to data among participants in the supply chain can play a significant role in achieving information transparency throughout the process [1]. Blockchain technology possesses characteristics that can be used in various sectors, and according to [1], it is a decentralized and public digital ledger where transactions are recorded and added in chronological order to create permanent and tamper-proof records. It achieves this by recording transactions in separate blocks, which are cryptographically linked to ensure high levels of security and validity. Each block is assigned a unique reference number or code, known as a “hash,” which is linked to the subsequent block via a link. This process ensures immutability, meaning if a specific block needs to be altered, all connected blocks must be modified accordingly [5 - 7].

In Brazil, the PROCEL Seal (National Program for Electric Energy Conservation) is a voluntary program designed to identify products with the best energy efficiency levels, benefiting society and companies while promoting their brand. PROCEL was created in 1985, coordinated by the Ministry of Mines and Energy (MME), and executed by ENBPar (Brazilian Company of Shares in Nuclear and Binational Energy). For equipment that uses fuels (gas, oil, gasoline, etc.) as an energy source, particularly for heat generation, the CONPET Seal is applicable with the same objective as PROCEL, promoting equipment efficiency and reducing emissions and resource consumption [8].

The Brazilian Labelling Program (PBE) was established in 1984 with a primary focus on improving energy conservation in the industry. Currently, it is coordinated and regulated by INMETRO (National Institute of Metrology, Quality, and Technology) [9]. The main objective of the PBE is to promote energy conservation by using informative labels on machinery and equipment that describe their energy consumption. To achieve this, the program implements technical standards for each type of equipment, encouraging continuous improvement in performance and equipment quality [8, 9].

In this first phase, the products undergo tests for electrical safety and efficiency levels following the RAC (Conformity Assessment Requirements) issued by INMETRO, obtaining the ENCE (National Energy Conservation Label) at the end of the process. The ENCE assigns an energy efficiency level to the product based on the tests, ranging from 'A' to 'D', with 'A' being the highest level of efficiency and 'D' the lowest. After approval in these stages, manufacturers/importers can request authorization to use the PROCEL seal, which is granted to the top 25% of most efficient products in the 'A' class of the same category [10].

According to [11], blockchain can be employed in the label process to reduce bureaucracy, improve data management, enhance information security, lower transaction costs, and increase the reliability, transparency, and audibility of the processes. It can generate new services such as certification of new products, evaluating equipment and buildings, monitoring the life cycle, and facilitating data correlation from certificates.

Furthermore, as stated in [12], blockchain can be applied in the equipment testing stages. Since the equipment submitted for the ENCE label must undergo tests in accredited laboratories, the standard NBR ABNT 17025:2017 applies, which establishes all the requirements that laboratories must meet to ensure traceability and result reliability. Blockchain can be adopted as the Digital Calibration Certificate (CCD) for the equipment used in the tests and throughout the process, using smart contracts.

Blockchain is already well-discussed in the literature regarding its application in the field of metrology. There is ample literature on the use of blockchain for digital calibration certificates, metrological traceability, smart contracts, and conformity assessment. For example, in [13], a system for managing and visualizing metrological traceability using Ethereum blockchain technology is presented. The goal is to provide an efficient and secure solution for managing digital calibration certificates (DCCs) and metrological traceability.

In [14], a model is proposed for the design of a blockchain network involving National Metrology Institutes and other organizations interested in promoting solutions related to legal metrology and conformity assessment. The work aims to present a permissioned blockchain architecture for creating a network composed of independent organizations with decentralized management, with a focus on application in legal metrology and conformity assessment. In [15], the existing literature on blockchain and legal metrology is reviewed, along with examples of use cases in other areas. Examples of how smart contracts and decentralized autonomous organizations can be applied in legal metrology systems are also presented. The objective is to explore the potential of blockchain technology in legal metrology, specifically in the areas of smart contracts and decentralized autonomous organizations. In [16], a vehicle speed measurement system was implemented using the Hyperledger Fabric platform. The author's objective was to propose a blockchain-based solution for implementing distributed measurement systems.

However, no literature was found that discusses the use of blockchain in conjunction with traceability for a conformity assessment process applied to energy efficiency labelling programs, such as the PROCEL Seal.

This work aims to propose an intelligent energy efficiency seal (smart label) using blockchain technology for secure access, traceability, validation, and certification of all information related to the energy performance of labelled equipment.

This work is structured into four sections. In this first one, the subject and other aspects related to the objective of this work were introduced. The second section provides a detailed description of the methodology applied in this work. The third presents the results, and finally, in the fourth section, the conclusion, final considerations, and suggestions for future work are presented.

2. Methodology

The methodology of this study involves mapping the process for granting the PROCEL seal of a typical household appliance from PBE, demonstrating the application of blockchain technology throughout the process stages. This process has nine steps, and five actors are involved, as can be seen in Figure 1: (i)

manufacturers/importers; (ii) INMETRO; (iii) accredited laboratories; (iv) PROCEL; and (v) consumers.

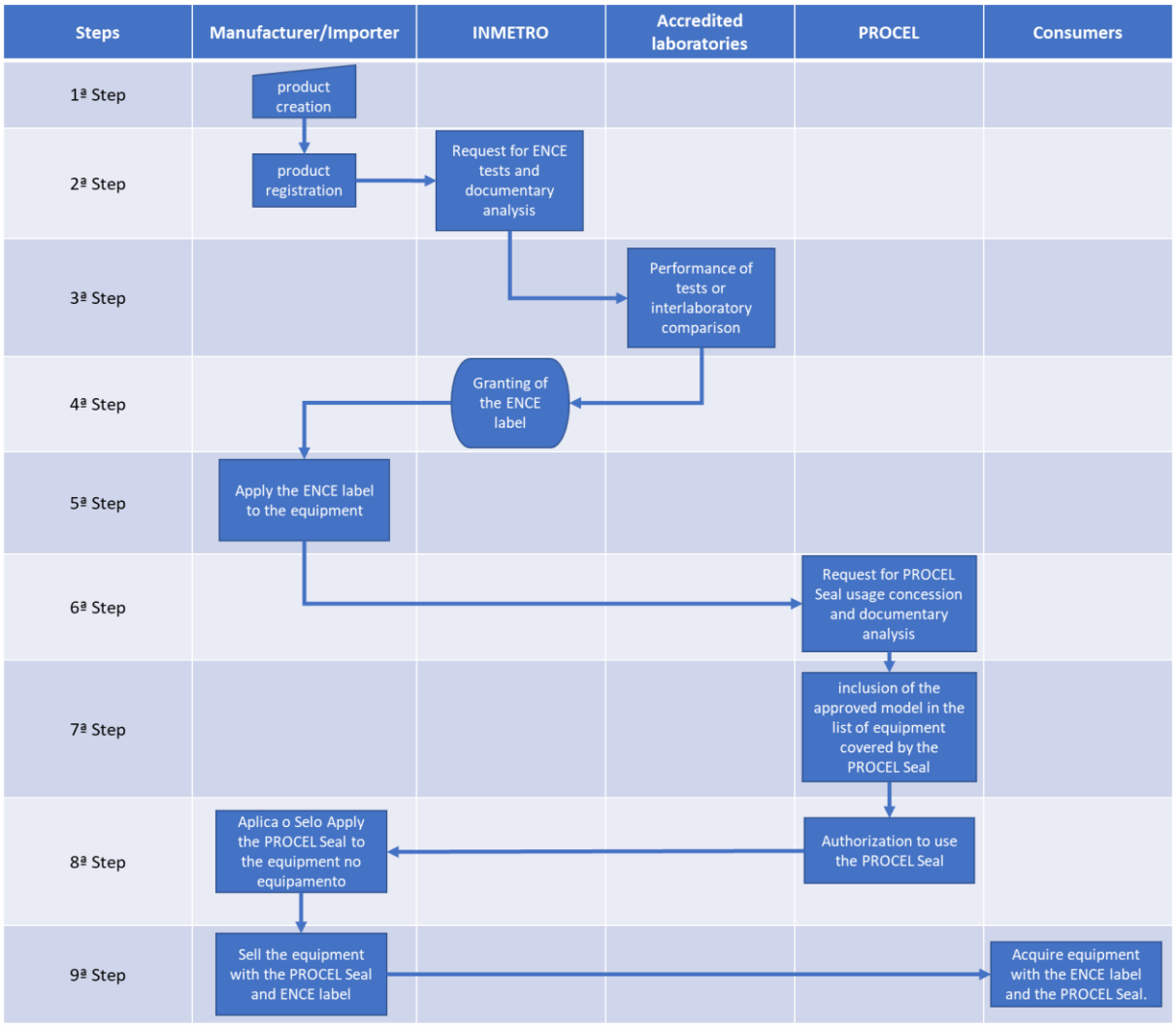

Figure 1. Main stages of the process for granting the PROCEL Seal.
Source: Own elaboration.

The summarized structure of the blockchain used in this work is presented in Figure 2.

In the utilized structure, at each stage of the process involving various stakeholders, as new information about the equipment is generated, an additional block is added to the information chain. When a consumer requests access to information about that equipment through the PROCEL Seal label, the entire chain is verified by a network of computers, following the chosen algorithm. Once the information contained in the chain about the equipment is validated, only the information previously authorized at the consumer level is ultimately presented.

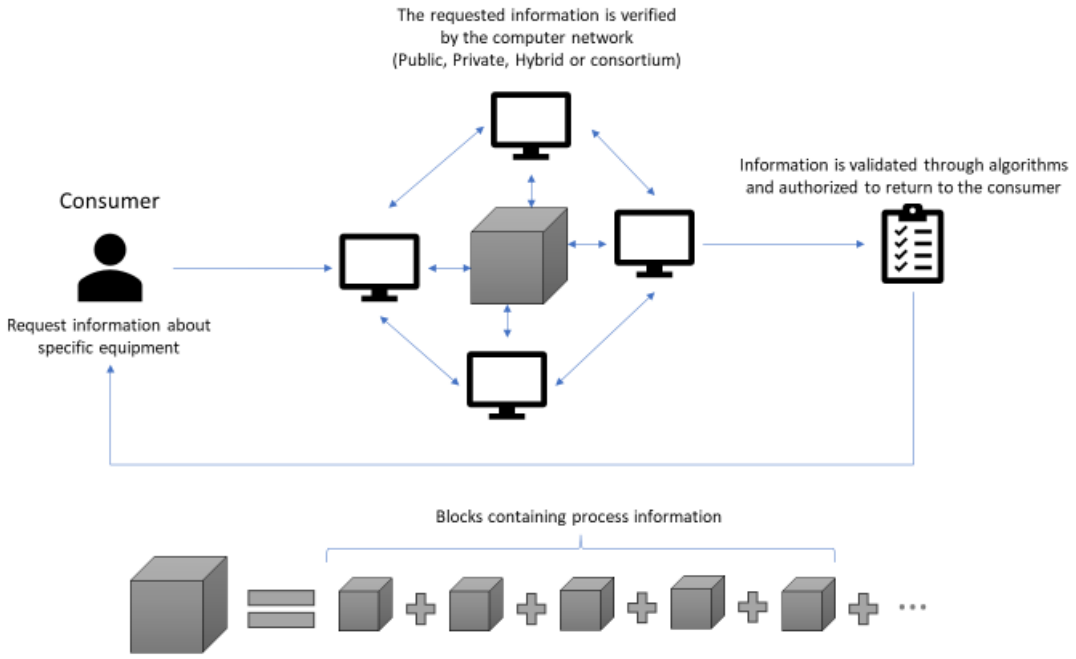

Figure 2. Summarized Structure of the Blockchain Used in the Study.
Source: Author's own elaboration.

Thus, following these principles and incorporating new features within the established framework, it was identified how blockchain could be employed at each stage of the product certification process until obtaining the PROCEL seal authorization and the product reaching the hands of the consumer.

3. Results / Demonstration of Applicability

As [11] stated, blockchain can be employed throughout the entire process to increase reliability, auditability, product certification, and transparency. The framework for granting the PROCEL seal to equipment using blockchain technology presents numerous advantages, such as traceability throughout the entire value chain process, from the conception and registration of the product to its end of life. Blockchain must be used by all the actors involved in the value chain, whether private or public entities. This tool can establish a unique system among all actors, providing secure information.

In Figure 3, the blockchain is applied within the first two stages of the PROCEL Seal granting process. These initial stages are internal processes and the responsibility of the manufacturer/importer. This study assumed the premise that these actors would use blockchain to demonstrate the potential results of using blockchain from the conception of product development. Information related to the research and development of the product is added with the insertion of the "A" information block. In the proposed framework, hash A contains all the information about the research and development of a new product. This may include information such as market research results, design, technical drawings, and all project management related to that product. This information is crucial for the company at this stage, and due to the security and immutability characteristics of blockchain, no unauthorized or undesirable changes would be possible, ensuring secure storage of the information. In hash B, information about the energy resources used in the equipment is added, such as the materials it will be composed of. In hash C, manufacturing information of the equipment is included, such as the manufacturing location, energy cost, production method, serial number, batch, and all relevant manufacturing process details. Finally, hash D encompasses information about the equipment registration, including the registration number, equipment category, registration location, patent registration process with the relevant authority, and other information related to the equipment's registration.

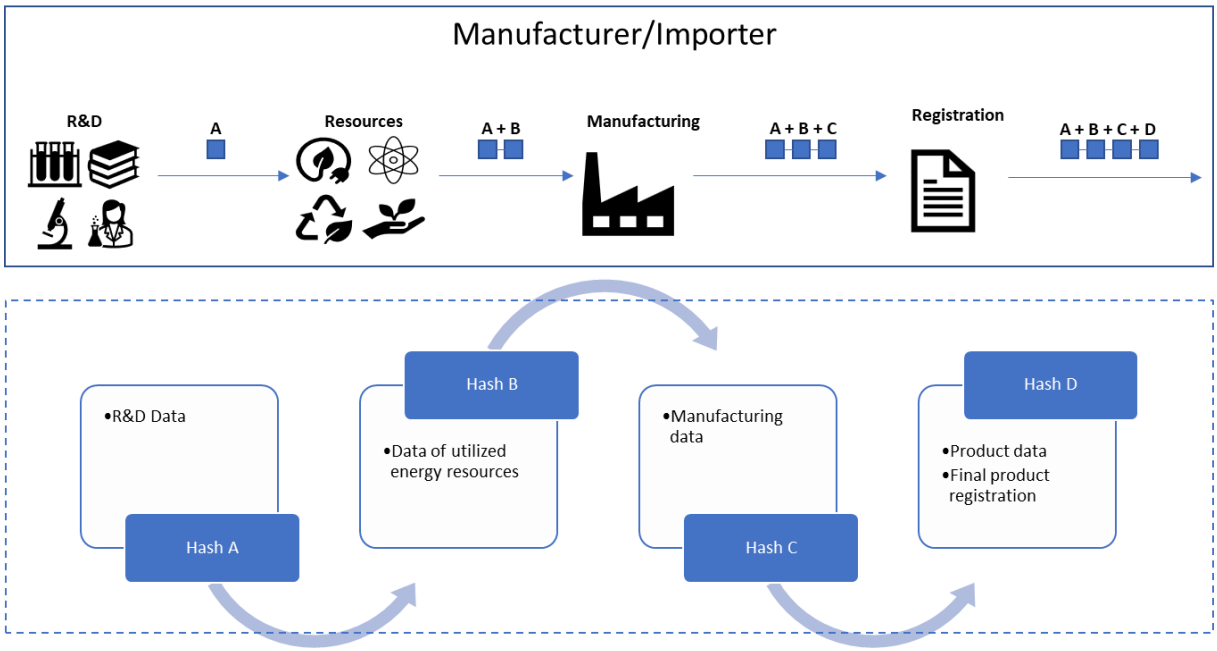

Figure 3. Stages 1 and 2 of the PROCEL Seal granting process and the blocks of information for each stage being inserted.
Source: Author's own elaboration.

Figure 4 encompasses the information from stages 3 to 5 of the process, starting with hash E, where the certification of the ENCE label is requested. This step is crucial because all manufacturers/suppliers wishing to apply for the PROCEL Seal for their equipment must already have the ENCE label on that equipment. In hash E, all the necessary documentation for certification is provided, and at this point, blockchain begins to interact between distinct actors: the company represented by the supplier/importer and INMETRO, responsible for reviewing the application. In hash F, information about the results of the analysis of the documentation provided by the supplier/importer is recorded. Hash G contains the results of the audit of the supplier/importer's quality management system (QMS), if required for certification. Hash H includes information related to laboratory tests, such as test plans, sampling for testing, the laboratory where the tests will be conducted, and the test results. At this stage of the process, when the tests are conducted, blockchain can play a significant role, as discussed in the literature. It can serve as digital calibration certificates, metrological traceability, smart contracts, and conformity assessment. In hash I, the conformity certificate for the ENCE label of the equipment is issued. After this step, the supplier/importer is authorized to affix the ENCE label to the requested equipment models.

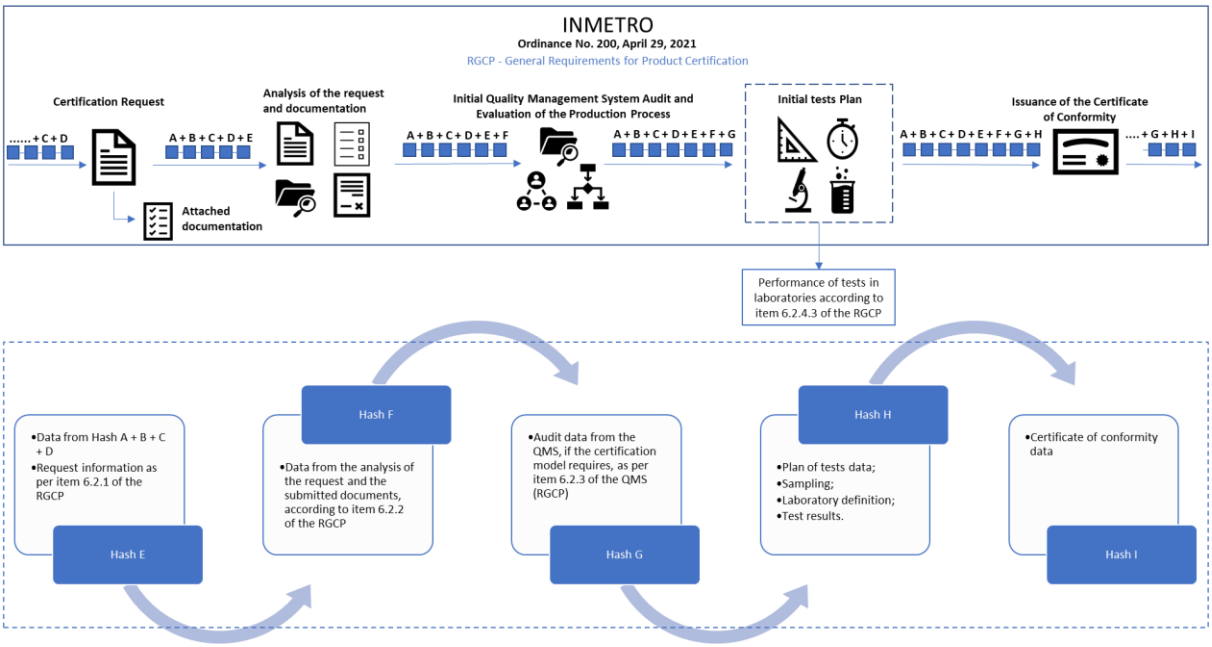

Figure 4. Stages 3 to 5 of the PROCEL Seal granting process and the information blocks for each stage being inserted.
Source: Author's own elaboration.

Figure 5 depicts stages 5 to 9 for obtaining the PROCEL Seal. In hash J, the supplier/importer initiates the request for the granting of the PROCEL Seal for a model of equipment that already holds the ENCE label certification. During this phase, the supplier/importer submits the necessary documentation for the request along with the request itself through hash I. Next, the blockchain interacts with another actor, PROCEL. In hash K, PROCEL conducts a comprehensive analysis of the request along with the digitally submitted documents. In hash L, after reviewing the request and documents, PROCEL adds the requested equipment model to the list of equipment covered by the PROCEL Seal. Hash M signifies the authorization granted to the supplier/importer to use the PROCEL Seal for the evaluated equipment model. The final hash in the process to be included in the blockchain is hash N, where the PROCEL Seal is affixed to the requested equipment model, allowing it to be offered for sale with the PROCEL Seal. Subsequently, consumers seeking information about the PROCEL Seal on the equipment can have confidence in the presented information due to the use of blockchain throughout the entire process chain, as well as the assurance that the product is genuine.

In the context of the PROCEL seal, Blockchain can transmit the entire life history of the equipment, including the steps it went through until it reached the hands of the consumer. As a result, the consumer can trace and verify the results of the tests to which the equipment was subjected, make comparisons between different equipment, understand the ecological impact of the product's development, and be assured that the product bearing the Blockchain-enabled PROCEL seal is not counterfeit.

By implementing blockchain in the framework of the PROCEL seal granting process, the actors involved, especially the consumer, will have access to all necessary information, with countless possibilities for additional data aggregation. This includes information on the ecological impact of the product during manufacturing, the manufacturing location, the company responsible for manufacturing and product registration, manufacturing date, serial number, warranty details, manuals, authorized technical support network, safety test performance, product certifications, as well as efficiency data and the PROCEL seal, among others.

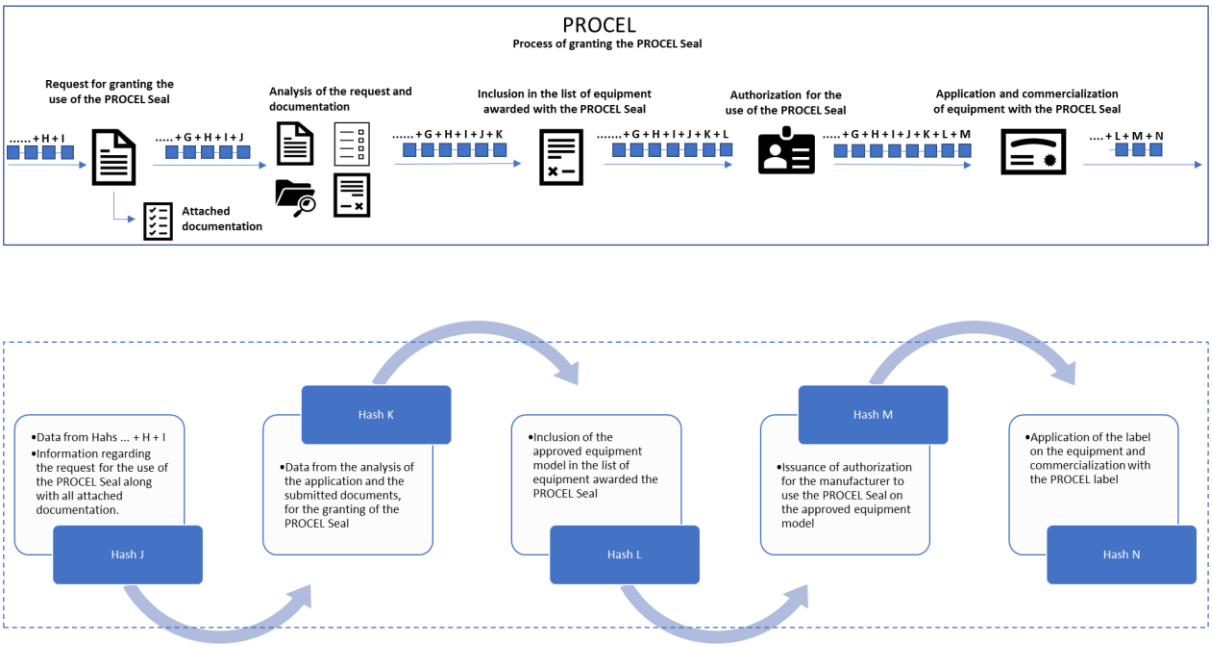

Figure 5. Stages 5 to 9 of the PROCEL Seal granting process and the information blocks for each stage being inserted.
Source: Author's own elaboration.

4. Final Considerations / Conclusions

Labels, tags, or energy efficiency seals are essential to achieve significant energy conservation levels. They are a tool present in numerous countries and drive the competitiveness for increasingly efficient products. Blockchain technology is increasingly integrated into productive sectors and processes across various fields, including product certification.

This study proposed a smart labelling system using blockchain in the certification process chain for the PROCEL seal. It demonstrated great potential for agility, transparency, security, interoperability, suitability, reliability, and traceability. Blockchain will soon become part of our daily lives thanks to its diverse range of applications.

As a recommendation for future work, this research envisions a more in-depth, detailed, and classified exploration of blockchain usage in product certification processes. This includes identifying blockchain functionalities used at each stage, as well as an in-depth exploration within the scope of the ABNT NBR 17025:2017 standard - General requirements for the competence of testing and calibration laboratories. Furthermore, the practical application of the proposed model in this study cannot be replicated, and it is recommended for future work to undertake such an application to provide a more detailed demonstration of the benefits, challenges, and improvements of Blockchain applied to energy efficiency certification processes.

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