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Development of a Web-Based Methodology for Sustainable Energy Generation from Chemical Waste Treatment †

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Abstract: Sustainability is crucial for technological development of a country, as it is closely intertwined with daily life and functioning of public and private institutions. It is not only a demand for national sovereignty, but it also has immense potential for reducing greenhouse gas emissions and solid waste, as highlighted in conventions such as The Intergovernmental Panel on Climate Change (IPCC) and UN Sustainable Development Goals (SDGs). This work aims to develop a methodology for generating energy from the treatment of chemical waste, using a fuzzy algorithm and converting it into a web platform. Therefore, 5 methodological steps were used for the web platform development, following the methodological aspects. *i.* Definition of the best web-interface methodology to explore the best technological development path. *ii.* Construction of an interface prototype using Figma. *iii.* Coding-implementation of step *ii.* *iv*-Tests. *v*-Coding. Through this web structure using an easy-to-use fuzzy model for practical energy sustainability for small and medium-sized companies, it is expected to improve industrial energy consumption through the reuse of discarded chemical materials. Hence, this project can help society, mainly the manufacturing sector of small and medium industries, the government sector to reach the goals of sustainable development, and the environment by reducing some pollutants with toxic characteristics and high solubility.

Keywords: Chemical Waste; Web Platform; Fuzzy Logic; Energy Sustainability

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1. Introduction

In this work, we present a comprehensive overview of our research topic, emphasizing its significance and outlining the primary components of the study. Our focus is to elucidate the central aspects of our work without delving into specific topics, such as sustainability, energy generation, or waste treatment. Instead, we aim to establish a broader context for the research at hand.

The optimization of energy generation from chemical waste faces several challenges, ranging from issues related to company infrastructure to the lack of public policies that promote this initiative. As emphasized by [1], energy efficiency (EE) should be a concern at all hierarchical levels of the industry, spanning from top management to lower-level employees. However, before implementing any action, obtaining an accurate diagnosis of the current energy consumption is essential. In this regard, the use of web interfaces and tools for industrial energy efficiency analysis simplifies this evaluation process, making it swift and accessible. This approach is particularly relevant for small and medium-sized enterprises (SMEs), allowing the identification of areas that can be improved and where energy consumption can be reduced.

The WEB application developed in this work aims to significantly contribute to the advancement of energy generation technologies from chemical waste, with a focus on the industrial sector. Through this platform, it is possible to calculate the specific energy efficiency of this sector, addressing essential topics related to the promotion of sustainability and responsible resource usage. As a result, this project seeks to benefit society, particularly the manufacturing sector of SMEs, the governmental sector in the pursuit of sustainable energy alternatives, and the environment by reducing pollutants with toxic characteristics and high solubility.

The novelty of this study lies in the creation of a web-based artificial intelligence platform, including fuzzy logic, to real-time analyze energy consumption derived from waste in industrial facilities. The uniqueness of this approach lies in the platform's ability to accurately predict energy demand peaks and automatically optimize the use of energy resources, adapting to variations in production and environmental conditions. This not only contributes to energy efficiency but also reduces operational costs for industries, minimizes environmental impact, and fosters a more resilient production environment. Furthermore, the platform can be integrated into existing energy management systems, making it a versatile tool for the industry with the potential to revolutionize how companies manage and utilize energy in their production processes.

2. Proposed Methodology

This study relies on carefully selected technologies to achieve its objectives, dividing into distinct stages that encompass everything from conception to the practical implementation of the solution:

1. Prototyping and Interface Design In the initial phase of prototyping and interface design, we turned to the FIGMA platform [2]. This tool provides a centralized approach, enabling the creation of the interface's appearance in a practical manner before its actual implementation.
2. Front-end Interface Coding Following the prototyping phase, our efforts were concentrated on front-end interface coding, utilizing the React technology [3]. React is a well-recognized library for creating User Interfaces (UI) on the platform, noted for its efficient updating and selective rendering of components in response to data changes.
3. Back-end Development and Database The implementation of interface functionalities in the back-end was achieved through the Dotnet platform [4]. Dotnet, a versatile development platform, was chosen for building all necessary applications. The back-end, in turn, maintains effective communication with the PostgreSQL database, selected for its prominence as one of the world's most advanced open-source relational database management systems [5].
4. Utilization of the Aforge Library for Fuzzy Methodology To further enrich the back-end, we incorporated the Aforge library [6], a highly valuable tool. We employed Aforge to translate the R code of the fuzzy methodology developed by [7]. This choice is justified by the wealth of classes available in the library, covering everything from fundamental concepts to complex challenges in fuzzy code implementation.

The seamless integration of these technologies culminated in the completion of this project, comprehensively meeting its objectives.

3. Analysis of Results

Upon the completion of the system, highly positive outcomes were achieved, as the application provides users with a valuable tool for industrial energy efficiency analysis, thereby contributing to cost reduction in the industrial sector and the enhancement of environmental quality. Furthermore, the use of this system will aid in achieving Objectives 2 and 7 of the main project, providing support and assistance to users [8].

The availability of this system in the project's GitHub repository [9] ensures accessibility and the dissemination of this valuable solution for industrial energy diagnostics. In which Figure 1 displays a portion of the web interface structure.

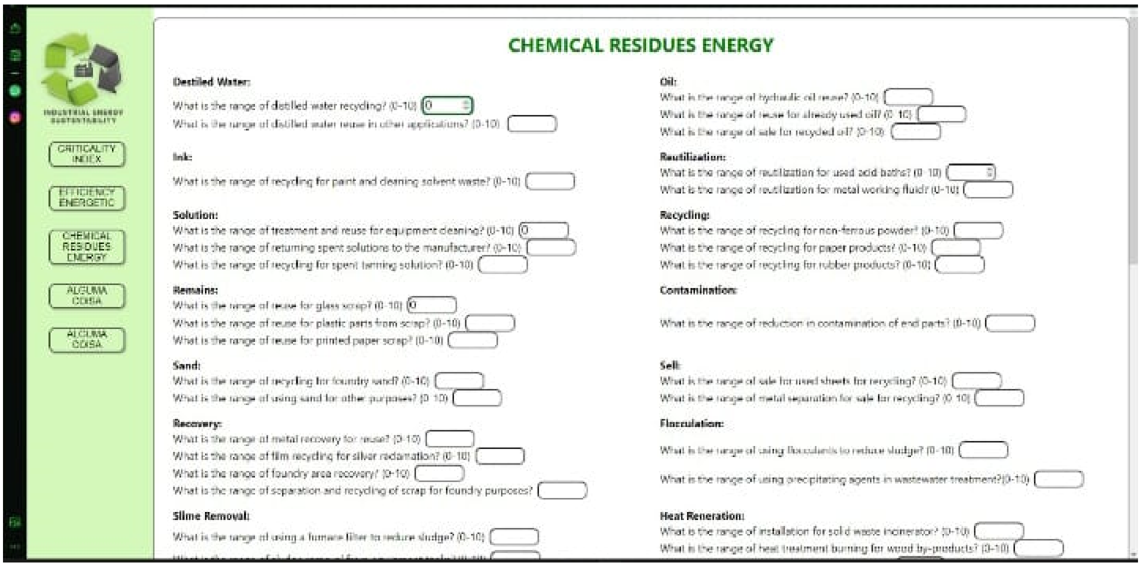

Figure 1. Web Interface Model of the system.

Considering that the industrial sector accounts for a significant portion of a city's total energy consumption, approximately 32.1% [10], alongside the transportation sector, which constitutes roughly 60% of the total consumption, focusing on the industrial sector is strategic. In recent years, there has been a growing demand for increased energy efficiency in industries, responsible for approximately 35.7% of a city's total energy expenditure [11].

Thus, the results of this work prove to be of great relevance for the energy diagnosis of industries, a crucial determinant for a city's progress towards urban intelligence. With this tool, a predominant contribution is expected towards reducing excessive energy consumption in the industrial sector, fostering significant advancements towards the creation of smarter and more sustainable cities.

In summary, the content of this scientific initiation represents a significant contribution to energy efficiency in industries and the development of smart cities. Through this system, industries will have a valuable tool at their disposal to identify and implement energy consumption improvements, thereby driving progress towards smarter and more responsible management of energy resources, aiming for a more sustainable future for cities.

4. Conclusions

Throughout this scientific initiation, a profound understanding of energy expenditures within the industrial sector and the significant influence of these expenses on environmental and economic impacts has been gained. The pivotal role of energy efficiency in driving the evolution of cities toward the category of "smart cities" has been highlighted.

With the conclusion and release of the developed system, it is anticipated that its utility will be widely recognized in future research and initiatives aimed at diagnosis and preventive measures in Brazilian cities. This platform facilitates the formulation of policies and strategies that assist cities in continuous improvement, progressing toward the status of a smart city.

It is worth noting that this system can be continually enhanced by adding new features and expanding into other relevant urban areas, such as transportation, according to the highest levels of energy consumption. This ongoing evolution presents a promising outlook for driving comprehensive and thorough city diagnostics, enabling the adoption of more effective measures and practices concerning energy efficiency and sustainability.

As the path paved by this scientific initiation is followed, it is hoped that numerous other applications or improvements based on this work will emerge, all contributing to a significant advancement in city diagnostics. Through this evolution, it will become more feasible to implement measures and actions that can further enhance the urban ecosystem and the economies of cities, ultimately providing a more sustainable and intelligent future for all. Commitment to the continuous development of these solutions is essential to promote the advancement of energy efficiency and the construction of smarter and more resilient cities for the well-being of communities and the environment.

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