
Kanjanapon Borisoot\textsuperscript{1,2}, Wanida Kanarkard\textsuperscript{1,3,*}, Tanakorn Wongwuttanasatian\textsuperscript{1,4}, Pichai Niltarach\textsuperscript{1}, Amnart Suksri\textsuperscript{1,5}, Kitt Tientanopajai\textsuperscript{3} and Denpong Soodphakdee\textsuperscript{4}

\textsuperscript{1}Centre for Alternative Energy Research and Development, Khon Kaen University, Thailand
\textsuperscript{2}Energy Engineering Program, Faculty of Engineering, Khon Kaen University, Thailand
\textsuperscript{3}Department of Computer Engineering, Khon Kaen University, Thailand
\textsuperscript{4}Department of Mechanical Engineering, Khon Kaen University, Thailand
\textsuperscript{5}Department of Electrical Engineering, Khon Kaen University, Thailand

Abstract. This paper introduces a novel platform of Waste-To-Energy Online Marketplace. The platform maintains a comprehensive catalogue of available biomass resources, detailing types, quantities, and geographical locations. This allows bioenergy facilities to identify and select suitable biomass feedstock based on their specific energy production requirements. Through an intuitive online marketplace, stakeholders can negotiate agreements, ensuring a streamlined and mutually beneficial exchange of biomass feedstock for bioenergy production. The online matchmaker by AI recommendation engine platform opens new avenues for biomass suppliers and bioenergy facilities to connect beyond traditional geographical and logistical constraints, fostering a more expansive and interconnected market. Efficient matching ensures that biomass resources are utilised optimally, reducing waste, and maximising bioenergy production. The proposed model seeks to enhance the efficiency of converting sugarcane biomass into bioenergy, leveraging digital and AI technologies to match biomass producers with bioenergy facilities, optimising the efficient conversion of biomass resources into renewable energy and fostering a reduction in GHG emissions associated with traditional waste disposal methods. This innovative approach has the potential to revolutionise the biomass supply chain, facilitating competitive pricing and cost-effective transactions, benefitting both biomass suppliers and bioenergy producers, promoting sustainability, efficiency, and collaboration in the journey towards a greener and more resilient energy future.

Keywords: Biomass, Bioenergy, Zero waste, Artificial Intelligence, Online Marketplace

* Corresponding author: wanida@kku.ac.th
1 Introduction

Thailand is commonly acknowledged as an agricultural-focused nation with a robust industry dedicated to the conversion of agricultural resources. This industry encompasses processing agricultural commodities into food products, raw materials, and a wide range of items and tools. Currently, Thai farmers primarily concentrate on cultivating sugarcane [1], resulting in a significant volume of biomass waste post-harvest. Despite agriculture serving as the historical backbone of Thailand, a considerable number of farmers lack the knowledge necessary for effective handling of agricultural waste generated after the harvest, leading to improper disposal practices. During the harvest season, there is a prevalent practice of incinerating these residuals, which gives rise to environmental problems that directly affect the daily lives of the population [2]. Despite efforts by the government to establish guidelines for the regulated transport of harvested and burned sugarcane to factories [3], the issue remains only partially resolved. Several factors contribute to the persistent burning of sugarcane plantations in Thailand, including insufficient support for harvesting labourers, the need for sugarcane farmers to acquire knowledge about managing biomass residuals from sugarcane leaves, and, most importantly, farmers who fail to recognise the value of utilising sugarcane leaf residuals to create alternative products. Addressing this challenge necessitates providing farmers with the requisite knowledge and skills for effectively managing challenging post-harvest biomass residuals. Moreover, fostering collaboration among diverse farmer groups across geographical locations is crucial for obtaining agricultural waste. Through these measures, the remaining residuals can be processed to enhance the sustainable value of biomass waste. The Alternative Energy Development Plan 2018–2037 (AEDP2018), the Thai government has implemented a policy to promote the use of renewable energy sources to make electricity, focusing on using biomass fuels [4]. Saleem [5] has pointed out that agricultural waste can serve as a viable fuel source for the sustainable generation of energy, with the energy content varying depending on the specific agricultural residuals. The biomass is agricultural waste left after the harvest, such as white straw, rice husks, tea leaf remnants, and sugarcane leaves discarded post-harvest. According to initial investigations, sugarcane leaves exhibit a heat value of up to 17.41 MJ/kg. Meanwhile, water hyacinth, rice straw, rice husk, and tea leaf residuals display calorific values of 14.81 MJ/kg, 15.09 MJ/kg, 16.47 MJ/kg, and 17.10 MJ/kg, respectively [6]. Thailand is the second-largest sugar exporter in the world, following [7], resulting in a significant surplus of sugarcane leaves post-harvest. According to findings by Dangprok et al. [8], the annual average quantity of residual sugarcane leaves left post-harvest in Thailand is recorded at 17,016 Kilotons. This considerable volume of agricultural waste remains underutilised. Currently available technologies and tools can be strategically employed to address this situation. Cano et al. [9] have noted that the upswing in electronic commerce has led to the emergence of electronic markets, serving as intermediaries in the transactional processes of buying and selling. These platforms bring together multiple vendors to offer a diverse range of products and services to consumers. Consequently, this phenomenon has the potential to significantly contribute to the enhanced sustainability of biomass supply. Flak [10] has compiled Information and Communications Technology (ICT), Internet of Things (IoT), and Industry 4.0 technologies used in biomass supply, including numerous exciting technologies such as precision agricultural tools, storage and logistics tools, and trading platforms. A problem for farmers is the need for a market for agricultural waste, which prevents the correct disposal of agrarian refuse. Farmers would benefit significantly from a platform for managing fundamental data, proposals, and sales. According to previous research, there have been efforts to establish an online marketplace to purchase and sell products, bringing buyers and sellers together to form a trading agreement. Qiang et al. [11] constructed a one-stop platform to promote the development of biomass fuel in China using the WeChat application for
telephone consultations and access to information on websites, as well as an analysis of the number of fuel types, provincial contribution, and fuel price distribution. Ninda et. al. [12] discusses the use of Artificial Intelligence in a startup matchmaking platform, which aims to bring together startups and partners through a matchmaking process. Lee et. al, [13] deployed the Artificial Intelligence-based job and education institution matching system that matches job seekers to job offers or provides job education information. Beguedou et al. [14] evaluate a mobile app-based digital platform that promotes a circular economy among farmers, suppliers, and industries to reduce trade barriers for alternative fuels and ensure fair and competitive farming business prices. Moreover, in alignment with the Thailand 4.0 policy, the Ministry of Digital Economy and Society launched the National Digital Economy and Society Development Plan and Policy for a 20-year period (2018-2037). This initiative aims to advance the nation towards a digitally empowered economy. Lilavanichakul [15] briefly summarises important policy support, one of which is the Department of Agriculture Extension's "Young Smart Farmers" program. The primary objective of this program is to alleviate marketing risks along with personal and labour risks in the agriculture sector. This is achieved through the enhancement of digital skills and agricultural capabilities, facilitating the integration of digital technology into smart farming systems and commercial operations. Consequently, this initiative has given rise to a regional online marketplace facilitating the buying and selling of various agricultural products. Illustratively, the DGT Farm platform, operated by the National Bureau of Agricultural Commodities and Food Standards, serves as a central online market where a diverse array of products, especially processed agricultural goods, can be acquired. Additionally, other platforms, such as the Thailand Post Mart platform [16] and the Hub Thailand platform [17] cater to local products and those involved in the One Tambon, One Product (OTOP) Project of Thailand, thereby supporting local businesses.

The challenge of utilising agricultural waste is widely recognised, primarily due to the dispersed distribution of such material at various locations within agricultural fields. To support the commercialisation of biomass, an online marketplace platform has been established, accessible through web-based and via a LINE mobile application. The Waste-to-Energy online marketplace platform offers advantageous features, including pricing and streamlining the matchmaking process between sellers and buyers. This aligns with the concept of zero biomass waste management, aimed at promoting the use of biomass. It also encourages sugarcane farmer groups to leverage agricultural waste materials for maximum benefit and sustainability. The main contributions of this study can be summarised as follows: This paper introduces an inventive and user-friendly technology designed for farmers, facilitating their access to digital tools and equipment for efficient storage and processing of biomass. This approach effectively mitigates the problem of agricultural waste incineration post-harvest, concurrently offering income-generating prospects for farmers. The online marketplace platform for biomass trading, operating under the Waste-to-Energy paradigm, is accessible through both a website and a LINE mobile application. this platform facilitates connections between individuals interested in purchasing biomass and those looking to sell biomass, thereby streamlining the trading processes for enhanced convenience. The rest of this paper is organised as follows. Section 2 introduces the Methodology. In Section 3, The Result and Discussion of this paper are presented, and the conclusion is presented in Section 4.
2 Methodology

The core principle of the zero-biomass waste management framework is to empower farmers in the proper disposal of biomass post-harvest, while concurrently providing biomass power plants with the requisite material for electricity generation. This study establishes guidelines for the efficient management of biomass waste, with a specific focus on the residues derived from sugarcane leaves post-harvest. The zero-biomass waste management concept entails the inclusion of biomass processing farmer groups as sellers of biomass, while buyers consist of sugar factories equipped with biomass power plants. Parameters governing transactions on this platform are intelligently determined by Artificial Intelligence recommendation engine based on considerations such as transportation distance, biomass fuel pricing, as well as the quantity and type of biomass fuel involved. Fig. 1 provides the zero-biomass waste management framework.

2.1 The framework of online marketplace for biomass

Upon gathering information about the issues and needs of biomass buyers and sellers, it became apparent that initially, biomass power plants (the buyers) and farmers (the sellers) contacted each other and established agreements to trade directly. However, this approach was limited, as it did not offer adequate options such as transportation distance, purchase price, biomass quantity, and biomass type. The online biomass marketplace platform presented in this paper offers the following primary service functions: selling biomass, purchasing biomass, searching for specific biomass, and suggesting potential biomass trading partners. Moreover, upon the completion of the buying and selling process, users have the opportunity to rate their partners, and the platform can also calculate the heat and energy generated from biomass trading, facilitating the assessment of reduced CO$_2$ emissions, as shown in Fig. 2. This platform was developed as a LINE mobile application and provided services on the website, making it accessible for use by biomass power plants in the northeastern region.

Fig. 1. Zero-biomass waste management concept.
2.2 Waste to Energy Marketplace platform

There are vital steps to follow in the Waste to Energy Marketplace within the biomass market platform, including registration and participating in the trading market. Trading agreements involve various details, as depicted in Fig. 3.

Step 1: Begin the registration process by logging in through the website (https://w2e.space) or the LINE mobile application (ID: @biomassmarket).

Step 2: Register using an email or a LINE account during the registration process.

Step 3: Once the registration identity has been verified, the user can log in using the username and password that the user has registered. After that, the user must fill in the profile details. The user must specify whether they are a buyer or seller biomass. Then fill in more information: name, address, telephone number, picture of the biomass of the buyer or seller, and specify the biomass you want to trade.

Step 4: When wanting to trade biomass, the user can provide specific details such as the location, the type of biomass, transportation, the quantity to be traded, and the price per unit. Also, the user can upload a photo of the biomass sample the user intends to buy or sell for searching and matching various buying and selling announcements.

Step 5: The match making system by A.I. recommendation engine provides recommendations and sorts potential matches to meet the needs of both biomass buyers and sellers. This intelligent matchmaking process aims to optimise the pairing of sellers, typically represented by biomass processing farmer groups, with buyers, which are often sugar factories equipped with biomass power plants. The Artificial Intelligence algorithms analyse various parameters, including transportation distance, to ensure efficient logistics and minimise environmental impact. Biomass fuel pricing is considered to establish fair and competitive transactions, fostering a sustainable biomass-to-bioenergy market. Additionally, the quantity and type of biomass fuel are factored into the matching process to align the specific energy needs of the buyers with the available biomass resources.

Step 6: The buyer and seller agree to the trade, which is considered a confirmed buy or sale. Both parties can rate each other. The evaluations given by trading partners who have executed transactions effectively function as a criterion for users to consider when choosing subsequent trading partners, as well as a mechanism for buyers and sellers to improve their transactions in the case of receiving low ratings.
3 Results and Discussions

To address the issue of limited access to sources for buying and selling biomass, an innovative online biomass marketplace platform has been developed. This platform is accessible through a dedicated website and a LINE mobile application to ensure convenience and widespread use. The LINE mobile application, a highly popular messaging, and social media platform in Thailand, saw significant adoption. As of 2019, according to the Hootsuite Analytics report [18], 84% of internet users in Thailand have active LINE accounts, making it the 3rd most popular social media platform in the country. This paper has leveraged both the website and LINE for its operations. The user interfaces for the online biomass market platform are presented in Fig. 4(a) for the website version and Fig. 4(b) for the LINE mobile application version.

Fig. 3. Workflows involved in utilising the Waste to Energy Marketplace.
Fig. 4. User-interfaces for the biomass marketplace platform (a) the website version (b) the LINE mobile application version.

Fig. 5. Analytical report: the computation of heat and energy generated through biomass trading.

Based on the practical utilisation of the online biomass market platform during the sugarcane harvest season, the online biomass market platform enabled the calculation of the heat and energy generated from biomass trading. These calculations are presented on the website of the platform, as depicted in Error! Reference source not found.(a) and Error! Reference source not found.(b), respectively. The online biomass marketplace platform is designed to facilitate trading not only in sugarcane leaves but also in other types of fuel, such as rice husks and rice straws, which are common agricultural products in Thailand. Furthermore, the website displays the reduction in carbon dioxide (CO2) emissions resulting from electricity generation using these alternative fuels, as illustrated in Error! Reference source not found.
Fig. 6. The reduction in CO₂ emissions resulting from the utilisation of biomass fuel for electricity generation.

4 Conclusion

This paper aims to establish comprehensive guidelines for the management of residual biomass generated from sugarcane leaves post-harvest under the framework of a zero-biomass management concept. The primary goal is to propose the innovative online biomass marketplace platform to foster the development of channels for biomass fuel trading, leveraging the online marketplace system available in website and LINE mobile application formats. The establishment of an online biomass trading platform serves as a crucial channel for the procurement and sale of biomass fuel. Within this platform, both buyers and sellers benefit from potential matches through A.I. recommendations, which consider criteria such as transportation distance, pricing, biomass quantity, and biomass type. By leveraging Artificial Intelligence in this matchmaking approach, the biomass-to-bioenergy supply chain can be optimised, promoting effective utilisation of biomass resources, minimizing waste, and contributing to a more sustainable and economically viable bioenergy industry. This streamlined process empowers stakeholders to make well-informed decisions regarding biomass trading. Noteworthy benefits of this platform encompass decreased transportation costs and heightened transparency in trading prices. Biomass power plants can, therefore, rely on a steady fuel supply for electricity generation, aligning supply with demand more effectively. For farmers, the platform provides an avenue to utilise existing biomass residuals, leading to additional income generation. Consequently, it establishes a sustainable solution promoting zero biomass waste management. Moreover, the online biomass trading platform possesses the capability to calculate the heat and energy generated post-biomass trading, facilitating the assessment of reduced CO₂ emissions.

The research team would like to thank the Centre of Alternative Energy Research and Development, Smart City Operation Centre, Khon Kaen University, for supporting our work.

References


