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Food2fuel: Converting Adversity Into Advantage By Maximizing Hotel Food Waste For Renewable Energy

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Abstract

Food2Fuel is an innovative application designed to reduce food waste and promote renewable energy use. The app connects food waste donors with biogas power generation companies that utilize food waste as an energy source. This initiative helps reduce food waste, lower dependency on fossil fuels, and decrease carbon emissions. Using the Pentahelix model, Food2Fuel fosters collaboration among five key stakeholders: the government, private sector, academia, community, and media. This inclusive approach enhances resource sharing, innovation, and the sustainability of the program. Food2Fuel offers significant environmental benefits by diverting food waste from landfills and repurposing it into renewable energy, mitigating its ecological impact. Economically, it creates opportunities in food waste processing industries and supports sustainable development. Socially, the app encourages community engagement and awareness of renewable energy. By integrating technology and stakeholder collaboration, Food2Fuel presents a comprehensive solution to food waste and renewable energy challenges. It addresses critical environmental, economic, and social issues, contributing to a more sustainable future.

Keywords: Food2fuel; Hotel; Renewable

1. Introduction

At a certain time, we often realize that the temperature getting warmer in the last several years. It was climate change that the Paris Agreement underscored will be the main issue for every country that needs to be solved by 2050. Specifically, every country should contribute to temperature management not exceeding 2°C by net zero emission strategy. Therefore, is needed transformational energy including reducing greenhouse gasses and optimizing the natural approach to achieve this mission [1]. Indonesia as fifth the most populous country plays a pivotal role in tackling this issue, as Indonesia contributes to a large amount of world emission gases through the daily activity of optimizing fossil fuel. In 2021, Indonesia produced around 600 million tonnes of CO_2, leading Indonesia to be the top 9th emitters in the world [2]

Biogas is a promising solution for Indonesia as a strategy for an energy transition that is environmentally friendly because produces fewer greenhouse gasses than fossil fuel [3]. To reduce dependence on solid biomass, like firewood as cooking fuel, biogas is the potential solution to be optimized. In Africa and Asia, biogas has the potential to provide environmentally friendly cooking fuel for approximately 200 million people by 2040 [4] .It implies that biogas is a reliable solution in transition energy strategy towards environmentally friendly and low carbon alongside electrical power mix [5].

Food waste serves as one of the key materials for producing biogas. According to the research data from EIU (Economist Intelligence Unit), the Food waste phenomenon in Indonesia has been steadily increasing over the years. Indonesia ranks second as the largest producer of food waste in the world after Saudi Arabia, with an estimated 300kg of food waste per capita annually (Kementan RI, 2019). This issue is exacerbated by the fact that 13.5% of Indonesia's population, totaling 269 million people, suffers from hunger (BPS, 2019). Ironically, the data above clearly indicates that Indonesia is one of the developing countries with a serious hunger index while also being the world's second-largest producer of significant food waste simultaneously [6]

Food waste contributes to greenhouse gas emissions, depletion of natural resources, and air pollution. Food waste has been a serious problem in the tourism sector because 10-42% of energy is used in hospitality. Around 1.6 kg of waste is produced per tourist per day. Organic waste is the biggest waste that tourists generate which consists of 7-72%. About one- third of hospitality

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waste is food waste. Of all food waste, 92% is plate waste (edible food left uneaten on guests's plates at the end of a meal) which can't be avoided [7]

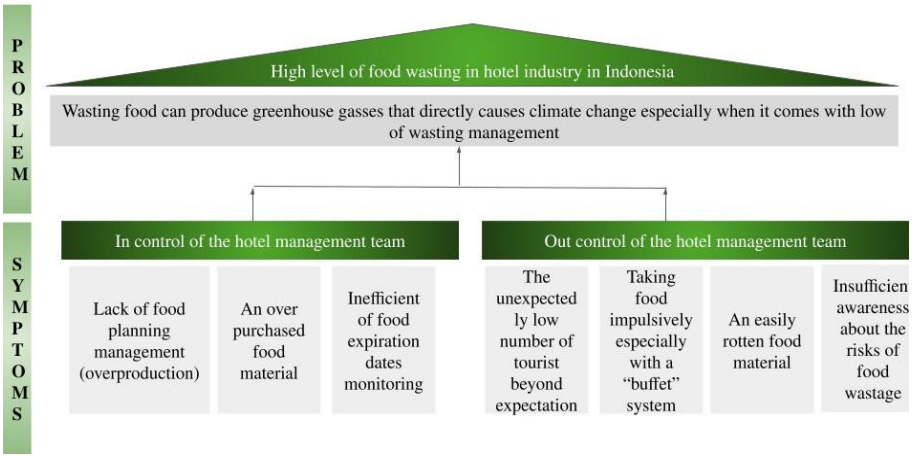

Figure 1. Issue tree framework (Author self-produced)

2. Literature Review

2.1. Tourism Pontential in Indonesia

In the era of globalization, tourism sector is a largest and most potential sector in financing in the global economy. Tourism has a strategic position in increasing the country's foreign exchange, primarily Indonesia, is known as a rich and diverse tourism potential [8]. In 2019, Indonesia received 16.1 million international tourists, and it recorded more than 370 million domestic trips. The tourism sector has been growing at an average annual rate of 5.4% of total GDP [9].

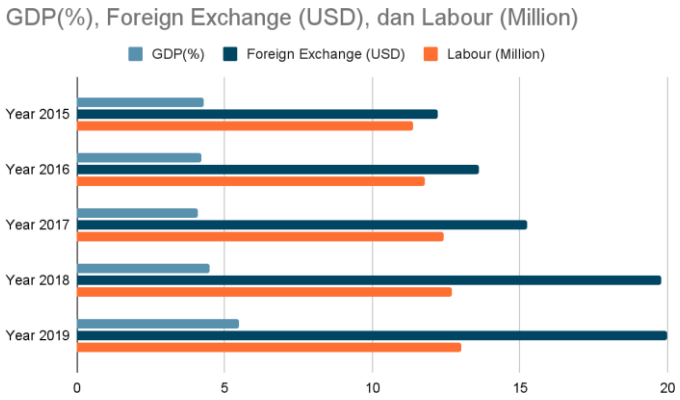

Figure 2. Growth of tourism impact (Ministry of Tourism Indonesia, 2020)

A significant increase in the number of tourist visits each year led Indonesia to generate a significant advantage in terms of revenue generator, Rupiah exchange rate strengthened, and wilder opportunities opened for employment [10]. To make tourism potential in Indonesia keep sustain, it need to meet the stakeholders, taking into account the economic impacts and current and future socio-cultural and environmental conditions. As a result, sustainability concept and its growth are a constant concern in the tourism sector. Furthermore, the objective of sustainable tourism is to minimize environmental damage, protecting the nature that often faces damage during tourism activities, such as increasing waste resulting to a new issue. A sustainable and responsible tourism is important to achieve Sustainable Development Goals to improve human life quality, prosper the current generation, and prepare a decent condition for future generations. It is important to develop tourism potentials in each region to be maximally utilized and managed for the community's welfare [10].

2.2. Hospitality Main Problem

Food waste makes up over 50% of waste in the hospitality industry and in the U.S., more than $218 billion is spent on growing, processing, moving, and discarding food that is never eaten [7]. Worldwide, hotel produce almost 300.000 tonnes of waste each year. It contributes to land exploitation, greenhouse gas emissions, and distracts wildlife, and limits biodiversity. All these negative

environmental impacts are expected to worsen in the next several years because tourism represents one of the driving forces of economic growth.

Proper waste management in the hospitality industry aims to reduce waste for a lower overall environmental footprint. Managing waste sustainability can also improve a hotel's reputation and appeal to environmentally conscious guests. Another crucial factor in implementing good waste management is the need for substantial investments in upgrading the infrastructure because of the many types of waste in the hotel industry [5].

3. Research Method

3.1. Research Method and Data

The research method employed in this study is descriptive with a qualitative approach. The author begins by analyzing a social problem, recognizing the significance of responsible tourism as a cornerstone of the green economy. It continued with data collecting and journal research to gather the supporting data. Data shows that food waste is a major cause of greenhouse gasses in Indonesia. This fact led authors to build an innovation to convert this adversity into advantage. Through Food2Fuel application, food waste will be efficiently delivered to biogas power plants. This innovative approach is deemed as a promising strategy for Indonesia's sustainable development efforts.

3.2. Data Collecting techniques

This research utilized previous research, such as ministry report data, a credible article, and a previous journal. By conducting a thorough review of existing literature, the author can gather relevant insights, theories, and empirical evidence. This approach enables researchers to build a solid theoretical framework, understand the current state of knowledge, and identify gaps or areas for further investigation. Additionally, literature studies provide valuable context and support for the author's findings, contributing to the credibility and validity of the study.

3.3. Data Processing and Analysis Techniques

The data processing and analysis technique employed in this study is the design thinking stage. Design thinking is recognized as a holistic approach to problem-solving that commences with empathizing with specific human-centred needs, leading to continuous innovation based on consumer or user requirements. The steps involved in executing design thinking are as follows:

Figure 3. Design Thingking (Texas University, 2024)

1. Empathize: This stage involves understanding the problem faced by general people, enabling the identification of solutions that resonate with their needs and experiences.
2. Define: This stage will focus shifts to analyzing and synthesizing the insights gained from the empathize process. The aim is to articulate the problem statement or main research concern.
3. Ideate: In this stage is the emphasis on generating creative ideas or concepts that serve as the foundation for developing a design prototype
4. Prototype: This stage entails creating an initial design or prototype based on the ideas generated, aimed at minimizing conceptual errors and refining the proposed solution
5. Test: The final stage involves testing the prototype with users to gather feedback and insights. The iterative process allows for refinement and iteration, with the possibility of revisiting the previous stage to address any identified issue or concerns.

3.4. Framework thinking

The author produces an innovative idea to tackle the main issue, such as the high level of food waste in the hotel industry in Indonesia. This main problem will be the production of greenhouse gases that directly cause climate change. It is against with world's mission to achieve net zero emissions by 2050. Furthermore, despite seeing this problem as a threat, the author converts it to the possibilities of energy security. The author uses this issue tree to make a solutive application for Indonesia.

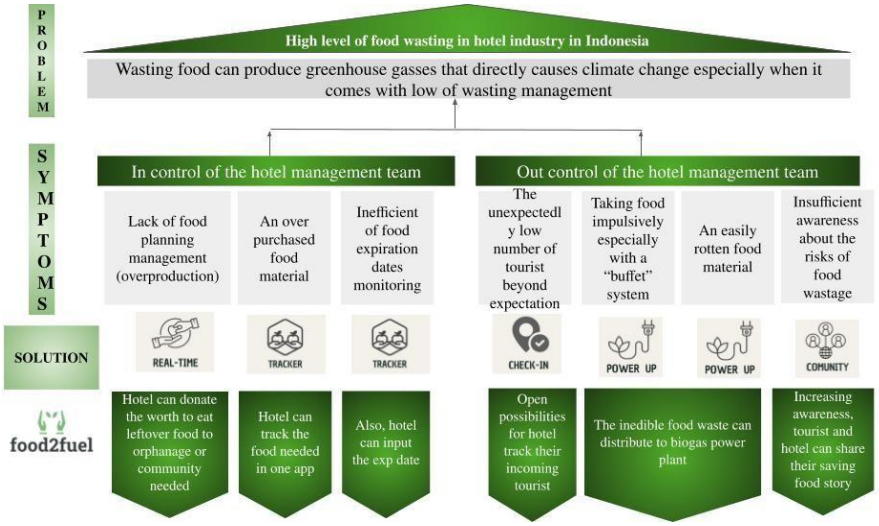

Figure 4. Framework Thinking

4. Results and Discussion

4.1. Food2Fuel concept as a Development Strategy for Food Waste Distribution to Biogas Power Plant

Food2Fuel is an application that focuses on food waste management. Food2Fuel is an app designed to reduce food waste while contribute to renewable energy in North Sumatra. The app allows hotels to input information about leftovers and waste food. Furthermore, the app matches with a nearby biogas power plant that can convert food waste into energy. Thus, Food2Fuel helps reduce the amount of food going to landfills while utilizing food waste as a renewable energy source. Food2Fuel itself has many advanced features that help its users to channel food waste to the biogas power plant in North Sumatra. Explanations of the application's feature are following to these:

1. Home page
   The main page contains the logo and tagline of the Food2Fuel application
2. Log in
   The "Log In" process in the Food2Fuel app is an important step that allows users to access their accounts and use the features of the app.
3. Home
   The home features (main features) contain of Power Up, Real-Time, Community, Tracker, Reward and Check-in. In addition to the home feature, there are social activities of Food2Fuel users such as their donation movements.

   a. Power Up
      The power-up menu is one of the key features that allows users to manage their food waste more efficiently. This feature includes theselection of the nearest biogas power plant. The app can display a list of nearby biogas power plant companies that can accept food waste. Users can select the company that best suits their needs andlocation for waste delivery. In addition, users can enter details aboutthe food waste to be delivered, such as the type of food, quantity, and condition (whether it has expired or will expire soon). This helps the biogas power plant company or organic waste treatment plant to prepare for the food waste treatment process appropriately.Then after selecting a biogas power plant company and also providing details about the food waste to be delivered, users can schedule a time for food waste collection. This feature allows usersto choose the time that is most convenient for them, ensuring that the waste collection process runs smoothly.

   b. Real Time
      The real-time feature on the Food2Fuel app that displays places thatneed food donations is an innovative solution to connect users whowant to donate their food with places that need food. This feature provides an opportunity for users to directly contribute to reducingfood waste and helping those in need. This real-time feature that displays places that need food donations makes the Food2Fuel appan effective platform for reducing food waste and helping those inneed. With this feature, we hope to create a more sustainable environment and a society that is more concerned about environmental and social issues.

   c. Community
      The community feature on the Food2Fuel app allows users to join communities that share the same interests and

goals of reducing food waste and supporting renewable energy. This feature opens upopportunities for users to interact, share information, and support each other in their efforts to protect the environment and contributeto sustainability.

With this community feature, the Food2Fuel app is not only an effective tool in reducing food waste and supporting renewable energy but also creates a space for the creation of a community thatcares about the environment and supports each other. This feature can be one of the factors that encourage users to remain active andcommitted to protecting the environment daily.

d. Tracker

The tracker feature on the Food2Fuel app is a tool that helps users to track and manage their food usage every month. It records food expenditure, food usage, and food waste data every month, and provides solutions to reduce food wastage. The tracker feature on the Food2Fuel app provides users with valuable information to helpthem manage their food usage more effectively and reduce food wastage. By utilizing this feature, it is hoped that users can becomemore aware of the importance of managing food wisely and contribute to protecting the environment.

e. Reward

The reward feature in the Food2Fuel application is a mechanism that provides incentives or rewards to users as a form of appreciation for their contribution in reducing food waste andsupporting the use of renewable energy. Where there are several levels of rewards in the food2fuel application, namely, beginners, contributors, partners, environmental experts and also main supporters.

The rewards feature on the Food2Fuel app is an effective way to encourage user participation in programs to reduce food waste andsupport the use of renewable energy. By incentivizing and rewarding users, it is hoped to create a more sustainable environment that is more aware of the importance of managing foodwisely.

f. Check-in

The check-in feature on the Food2Fuel app is a feature that allowsusers to tag or "check-in" at hotels or other venues that work with Food2Fuel. The main purpose of this feature is to raise public awareness about hotels participating in the Food2Fuel program andpromote the eco-friendly practices undertaken by these hotels.Through the check-in feature, other hotels may also be inspired to join the Food2Fuel program. By seeing the positive impact that the program is having on the hotels that are already participating, otherhotels may feel interested in joining the effort to protect the environment.The check-in feature on the Food2Fuel app has the potential to provide great benefits to the hotels participating in the Food2Fuel program, the community, and the environment. By increasing public awareness of the hotels' eco-friendly practices, it is hoped that a broader positive impact can be created in the effort tomaintain environmental sustainability.

g. Chat

The chat feature allows users to interact, exchange information, and share experiences with other users who share the same interest inreducing food waste and renewable energy. This can expand users' social networks and increase their sense of solidarity in their efforts to protect the environment. The chat feature on the Food2Fuel app is an effective tool for facilitating communication and collaboration betweenusers, as well as strengthening communities that care about the environment. By utilizing this feature, users can support each other andbe inspired to contribute to environmental sustainability.

h. New Post

The "New Post" feature on the Food2Fuel app allows users to createand share new content, such as articles, photos, or videos, related to reducing food waste and renewable energy. The "New Post" feature allowsusers to share information and knowledge about practices that can be doneto reduce food waste and support renewable energy. These contents can educate other users about the importance of protecting the environment.

In addition, users can use this feature to share stories, experiences,or tips that can inspire and motivate other users to participate in efforts to reduce food waste. This can help create a community that cares more aboutthe environment. The "New Post" feature on the Food2Fuel app is an effective tool to expand knowledge, raise awareness, and build a community that cares about the environment. By utilizing this feature, users can actively contribute to efforts to maintain environmental sustainability and support the use of renewable energy.

i. Notifications

The notification feature that notifies users when other users like or followthem on the Food2Fuel app is a feature that enables social interaction between users. Notifications about other users liking or following them canincrease users' motivation to continue to be active in contributing to the Food2Fuel program. This can give users a feeling of being appreciated andmotivated to continue participating.

j. Profile

The profile feature on the Food2Fuel app allows users to create and managetheir personal profiles within the app. The profile feature allows users to store their personal information, such as their name, profile photo, and other contact information. This helps other user to get to know them betterwithin the Food2Fuel community.

4.1.1. Food2Fuel design thinking concept

The Food2Fuel app is designed with a focus on the user and its primary goal of reducing food waste and supporting renewable energy. The design of Food2Fuel; takes into account the needs and preferences of users in daily use to provide a relevant, useful and meaningful experience. The design thinking concept of the Food2Fuel app reflects the values of environment, sustainability and collaboration. An eco-friendly design can also reflect the app's mission of supporting sustainable practices.

In planning the development of the Food2Fuel concept using a design thinking approach. Design thinking is a very relevant approach in making the Food2Fuel application because its main focus is on a deep understanding of the user and the problem to be solved and design thinking is a framework used for problem solving by generating new ideas that focus on users or humans. Here are the reasons why using design thinking in the creation of the Food2Fuel application:

1. Emphatize
   Based on the data obtained from BPS, scientific journals, news and other sources, the real problems in North Sumatra Province can be formulated as follows:
   a. **Food Waste:** Based on a BPS study, North Sumatra wastes around220,000 tons of food annually, which is equivalent to 44 million servings of food. This wastage is caused by various factors such asoverstocking, close expiration dates, and unmet beauty standards.
   b. **Public Health:** According to data from the North Sumatra Health Office, there has been an increase in cases of food-related illnessessuch as diarrhea, food poisoning, and gastrointestinal infections. This is caused by the consumption of food contaminated by bacteriaor harmful chemicals from food waste.
   c. **Awareness and Education:** A survey conducted by the Universityof North Sumatra shows that most people are still not aware of theimportance of managing food waste.
2. Definition
   After understanding the problems faced by the users, the next step is to clearly define the objectives and problems that the Food2Fuel app aims tosolve. This will serve as a guide in designing an appropriate and effective solution.
3. Ideate
   In this stage, the development team will generate various ideas and concepts to solve the defined problem. These ideas may involve different features, mechanisms or strategies to reduce food wastage and support renewable energy.
4. Prototype:
   Once the ideas have been collected, the next step is to create a prototype ofthe Food2Fuel app. This prototype could be a simple view of the user interface or key planned features, which will be tested with potential usersto get initial feedback.
5. Test
6. The prototype will be tested with potential users to identify the strengths and weaknesses of the design and features. The test results will be used torefine and further develop the prototype.
   Through this design thinking approach, developers can ensure that the Food2Fuel app is developed based on a deep understanding of user needs and the problem it aims to solve. This will help in creating an effective anduseful solution for the community in managing food waste and supportingrenewable energy.

4.1.2. Comparison betweenFood2Fuel and other apps

Indicator	**Innovation Comparison**		
	Food2Fuel	Too Good To Go	OLIO
	food2fuel	was founded by a group of people consisting of Chris Wilson, Jamie Crummie, Thomas Skinner, and James	was founded by Tessa Clarke and Saasha Celestial- One in 2015.

		Roy Poulter.	
Objective	Reducing food wastage by diverting the food waste generated by the hotel to a biogas to be used as a renewable energy source. Thus, this application has two main objectives, namely reducing food wastage and supporting renewable energy.	Reduce food wastage by allowing users to purchase leftover food at discounted prices from restaurants and food stores.	Reduce food wastage by allowing users to give their excess food to others in their community.
Features	The power up feature allows users to donate their foodwaste to a biogas power plant to be used as a renewableenergy source. Inaddition, Food2Fuel also provides real-time, community, tracker, reward and check in features.	Provides a list ofparticipating restaurants and food stores, allows users to order food at discounted prices,and directs users topick up food at designated locations.	Allows users to post photos of the food they want to give away, view the food available around them, and set a time and place for pickup.
Comparison	Food2Fuel has a more holistic approach in addressing the issue of food wastage, byoffering a morecomprehensive solution that includes utilizing food waste for renewable energy and waste management	Too Good To Go focuses on the redistribution ofleftover food from food businesses to end consumers,while Food2Fuel is more orientedtowards the overall management of food waste, including the use of waste	OLIO focuses more on food redistribution fromindividual to individual, whileFood2Fuel has a broader focus, including the utilization of foodwaste for renewable energy and food waste management.

4.2. Food2Fuel Implementation Strategy

In its implementation, Food2Fuel considers the objectives to be addressed in accordance with the SMART (Specific, Measurable, Achievable, Relevant, and Time-bound). SMART analysis as follows:

Specific	• Hotel as the target of program implementation • Private sector as investor and capital provider • Government as the regulator • Academics as initiators and designers in identifying problems and potentials • Mass media as a medium to distribute publications
Measurable	• Food2Fuel can increase public knowledge in various aspects related to food waste management and renewable energy. • Food2Fuel can be implemented by optimizing cooperation with hotels in several ways that can increase the effectiveness of the program. • Innovations in Food2Fuel, such as the use of environmentally friendly technology to convert food waste into renewable energy, can increase public interest as it provides concrete solutions to two important issues: food waste and sustainable energy use.
Achievable	The implementation of the Food2Fuel program is in accordance with the program in realizing the Sustainable Development Goals (SDGs), especially points 12.3 and 7.2.
Relevant	Food2Fuel can be implemented after the application is structured and organized with an estimation of 1 - 2 years. Food2Fuel will be successful after going through the stages of planning, technology development, testing, launching, monitoring, and development of a mature and effective community

Time-Bound	• Short Term: within 1 - 2 years • Medium Term: within 3 - 5 years • Long Term: within 5+ years. **Appendix 2**

Food2Fuel has short-term targets (1-2 years) that focus on technology development, marketing, and community acceptance. The goal is to expand the partner network, increase the number of users, and optimize the process of managing food waste into renewable energy. Within this timeframe, the app can achieve significant levels of participation and usage in the target region or community. While in the longer term (+5 years), Food2Fuel can become an integral part of the city or regional infrastructure, with a high level of participation from the public and industry. The application can play an important role in changing the paradigm of food waste management and renewable energy at large. The goal is to achieve significant impact in reducing food waste, supporting renewable energy, and shaping more sustainable behavior in society.

The Food2Fuel concept works together with stakeholders such as the community, private sector, government, academia and mass media in accordance with the pentahelix concept. This concept is a development of the triple helix model that involves interaction between universities, industry and government. According to [11] in the Pentahelix concept, the five main elements involved in innovation and development are universities, industry, government, society and mass media. Etzkowitz sees that collaboration and partnership between these five elements is crucial in creating an enabling environment for innovation and sustainable development. In Food2Fuel, every stakeholder has an important role to play in supporting the success and positive impact of the program:

1. Community
   Communities play a key role in Food2Fuel as both donors and beneficiaries. Communities can play a role in donating food waste that is still fit for consumption, as well as being beneficiaries by accessingrenewable energy generated from the food waste. The community also plays an important role in disseminating information about the program and raising awareness on the importance of managing food waste wisely.
2. Private Parties
   The private sector has a role as a partner in the development and operationof Food2Fuel. Private companies can play a role in donating their food waste, as well as investing in the technology and infrastructure needed to convert food waste into renewable energy. The private sector can also assistin promoting the program and increasing community participation.
3. Government
   The government has an important role in creating policies and regulationsthat support the Food2Fuel program. This includes food waste management, renewable energy, and incentives to encourage community and private sector participation in the program. The government can also act as a partner in providing the necessary infrastructure to support the program.
4. Academia
   Academics can play a role in Food2Fuel through research and developmentof more efficient and environmentally friendly technologies to manage food waste. They can also play a role in providing education and training to the public on proper food waste management and renewable energy utilization
5. Mass Media
   Mass media plays an important role in disseminating information about theFood2Fuel program to the general public. Through media coverage and campaigns, the program can gain greater attention from the public and support increased participation and support. The implementation of Food2Fuel involves several stages that are essentialto ensure the success of the program. The following is a breakdown of theFood2Fuel implementation stages:
   a. **Planning:** The initial stage is careful planning, including identification of program objectives, determination of target audience, market analysis, and development of a suitable business model.
   b. **Technology Development:** Development of applications and technologies required to manage food waste into renewable energy. This includes the development of digital platforms, waste management systems, and energy conversion technologies.
   c. **Testing:** Once development is completed, thorough testing of the application is done to ensure good performance, data security, and ease of use.
   d. **Launch:** After successful testing, there is an official launch of the Food2Fuel app. This may involve marketing and promotional campaigns to increase public awareness and participation.
   e. **Management and Maintenance:** After the launch, the program requires good management and continuous maintenance to ensure that its performance remains optimal and meets user needs.
   f. **Community Development:** It is important to continuously develop the community of users, partners, and other

stakeholders to expand the network and increase participation in the program.

g. **Evaluation and Updates:** On a regular basis, the program is evaluated to see the achievement of objectives and identification of areas of improvement. Based on the evaluation results, the program is regularly updated and improved.
h. **Scalability:** Over time, Food2Fuel can serve as a model that can be scaled up and implemented on a larger scale to achieve broader impact in reducing food waste and supporting renewable energy

4.3. Food2Fuel Implementation Strategy

The development of Food2Fuel has significant benefits in various aspects, including economic, social, and environmental factors.

a. Economic Aspect
Economically, Food2Fuel can help reduce food waste management costs for households, restaurants and the food industry by converting food waste into renewable energy sources. This can reduce the cost of disposing food waste to landfills and even generate additional revenue through the sale of the renewable energy produced.

b. Social Aspect
Food2Fuel can help reduce inequality in access to food by facilitating the redistribution of food that is still fit for consumption to those in need. This can help address hunger and strengthen social solidarity within communities. In addition, Food2Fuel can also serve as a platform to build public awareness on the importance of managing food waste responsibly and supporting sustainable practices.

c. Environmental Aspect
Food2Fuel can help reduce the negative impact of food waste disposal on the environment. By converting food waste into renewable energy, Food2Fuel can reduce greenhouse gas emissions resulting from the decomposition of organic waste. In addition, the use of renewable energy from food waste can also reduce dependence on non-renewable fossil energy sources and reduce environmental pollution.

4.3.1. Analysis of Benefits to Government Programs

The analysis of the benefits to government programs of the Food2Fuel app includes various positive aspects that can significantly contribute to government goals and policies related to food waste management and renewable energy. One of the key benefits of Food2Fuel is its ability to reduce food waste by diverting previously discarded food waste into renewable energy sources. This is in line with government programs that aim to reduce food waste and create a more sustainable circular economy.

Benefit analysis against existing government programs, such as the Sustainable Development Goals (SDGs), of the Food2Fuel app can provide a clearer picture of the app's contribution to the achievement of sustainable development goals. One of the key benefits of Food2Fuel towards the SDGs is its contribution towards achieving SDG Target 12.3, which is to reduce food waste at the consumer level and throughout the food supply chain. By diverting food waste into renewable energy sources, Food2Fuel helps reduce food waste at the household, restaurant and food industry levels.

In addition, Food2Fuel also supports the achievement of SDGs Target 7.2, which aims to increase access to renewable, affordable and clean energy. By using food waste as a renewable energy source, this application can help increase access to renewable energy, especially in areas that are difficult to reach by conventional energy sources. This has a positive impact on increasing energy access for people who do not have adequate access.

5. Conclusion

Based on the description of the problems and solutions above, it can be concluded that:

1. Food2Fuel is an innovative app that changes the paradigm of food waste management. The app provides an innovative solution by utilizing technology to connect food waste donors with parties in need, such as biogas power generation companies that use food waste as a renewable energy source. By using the Food2Fuel app, people can easily donate unused food that is still fit for consumption, while power companies can obtain renewable energy supplies from this food waste. This not only reduces food wastage, but also helps to reduce dependence on fossil energy sources and reduce carbon emissions.
2. The implementation of Food2Fuel applies the Pentahelix concept that involves cooperation between five main parties, namely the government, the private sector, academia, the community, and the mass media. The government plays a role in creating policies that support this program, such as regulations related to food waste management and renewable energy. The private sector contributes to the development of technology and infrastructure needed to manage food waste into energy. Academics assist in research and development of more efficient technologies to convert food waste into

renewable energy. Communities act as both food waste contributors and beneficiaries of the renewable energy produced. While the mass media helps in disseminating information and raising public awareness on the importance of food waste management and renewable energy.

3. Food2Fuel is expected to provide great benefits in several aspects. First, in terms of the environment, the program is expected to reduce food waste, which is a serious problem in many countries. By utilizing food waste as a renewable energy source, Food2Fuel can help reduce the amount of food waste that goes into landfills, thereby reducing its negative impact on the environment.

In addition, Food2Fuel is also expected to provide economic and social benefits. By creating a new market for food waste that can be processed into energy, the program can create new economic opportunities, such as the food waste processing industry. In addition, the use of renewable energy from food waste can also reduce dependence on fossil energy sources, thus making a positive contribution to climate change mitigation efforts. Thus, Food2Fuel is expected to provide extensive benefits to society, the environment, and the economy.

References

[1] Bistline, J. E. (2021). The urgency of energy transformation to reduce greenhouse gas emissions. *Climate and Energy Studies*. "An Energy Sector Roadmap to Net Zero Emissions in Indonesia" (2022). Ministry of Energy and Mineral Resources, Indonesia.
[2] Struk, M. (2020). Biogas as a sustainable solution for energy transition. *Renewable Energy Research Journal*.
[3] Kasinath, A., et al. (2021). The potential of biogas in Asia and Africa for clean cooking solutions. *Global Sustainable Energy Report*.
[4] Baena-Moreno, F. M., et al. (2019). Renewable energy technologies for reducing carbon emissions. *International Journal of Energy Research*
[5] Bambang Hermanu (2022). Analysis of food waste as a contributor to greenhouse gas emissions in Indonesia. *Environmental Sustainability Review*.
[6] Juvan, E., Grün, B., & Dolnicar, S. (2023). Food waste management in the hospitality industry: Challenges and solutions. *Journal of Sustainable Tourism*
[7] Firdaus, H. (2018). Leveraging Sustainable Tourism for Economic Growth in Indonesia. *Tourism Development Journal*, 14(5), 451-467. Highlights tourism's contributions to Indonesia's economy while advocating for sustainability.
[8] PwC Indonesia (2024). Growth and challenges in the Indonesian tourism sector. *Tourism and Economic Development Insights*.
[9] Kawuryan, R., et al. (2022). Sustainable Tourism Development in Indonesia: Current Trends and Future Goals. *Tourism and Environmental Studies*, 19(4), 223-235. Explores sustainable practices in tourism for long-term growth.
[10] Etzkowitz, H. (2000). The Pentahelix Model: Collaborating for Innovation and Sustainability. *Innovation Management Journal*, 18(3), 289-305. Introduces the Pentahelix concept integrating stakeholders for sustainable innovation.