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Analysis of Promotion Policies for the Valorization of Food Waste from Industrial Sources in Taiwan

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Abstract: Growing concern about circular bioeconomy and sustainable development goals (SDGs) for the valorization of food waste has raised public awareness since 2015. Therefore, the present study focused on the promotion policies and regulatory measures for the valorization of mandatory recyclable food waste from industrial sources in Taiwan, including the animal/plant production farms and food-processing plants. According to the official data on the annual statistics during the period of 2015–2019, it showed that the food waste from alcoholic beverage manufacturers (i.e., lees, dregs, or alcohol mash) and oyster farms (i.e., waste oyster shell) accounted for about half (about 250,000 metric ton) of industrial food waste generation in Taiwan. In order to effectively reduce the burdens on incinerators/landfills and their environmental impacts, the central governing agencies jointly promulgated some regulatory measures for promoting the production of biobased products from the industrial food waste valorization like animal feed, soil fertilizer, and bioenergy. These relevant acts include the Waste Management Act, the Fertilizer Management Act, the Feed Management Act, and the Renewable Energy Development Act. In addition, an official plan for building the food waste bioenergy plants at local governments via anaerobic digestion process, which was estimated to be completed by 2024, was addressed as a case study to discuss their environmental and economic benefits.

Keywords: industrial food waste; valorization; biorefinery; bioenergy; biobased materials; promotion policy

Citation: Tsai, W.-T.; Lin, Y.-Q. Analysis of Promotion Policies for the Valorization of Food Waste from Industrial Sources in Taiwan. *Fermentation* **2021**, *7*, 51. https://doi.org/10.3390/fermentation7020051

Academic Editor: Alessia Tropea

Received: 1 March 2021
Accepted: 1 April 2021
Published: 5 April 2021

1. Introduction

Growing concern about circular bioeconomy, hunger, resource conservation, and sustainable development associated with food loss and waste (FLW) has raised public awareness in recent years [1,2]. With t he changes in diet habits and the improvement of living standards, many food waste has been generated from residential, commercial, and institutional sources, such as retails, wholesales, restaurants, hospitals, schools, and hotels, as well as from industrial sources like food processing plants, animal-breeding farms, crop/vegetable/fruit farms, and employee lunchrooms [3,4]. The discarded food often contained vegetable leaves, leftover meals and grains, fruit peelings, dairy, oils/grease, salts, and water. Due to its constituents like lignocelluloses, protein, and oils and grease, such wastes without valorization for the production of value-added materials and/or bioenergy would imply the resource depletion and wastage. Moreover, the environmental concern could be derived from their compositions, which may cause negative effects on the environment (e.g., odors, vectors, emission gas emissions, or climate change) if they are illegally disposed of in dumping sites or fields [5]. In addition, these food discards may be rich in the moisture and nutrient compositions, thus causing wastewater discharge with high biochemical oxygen demand (BOD) and/or chemical oxygen demand (COD) values in the landfill leachate [6]. For these reasons, the valorization of food waste has become increasingly important in recent years due to the United Nations (UN) Sustainable Development Goals (SDGs) and national regulatory requirements [7]. Therefore, the reuse of food waste as a valuable resource for the production of materials, fertilizer, and biofuels has been reviewed recently [7,8].

As mentioned above, FLW has become one of vital issues raised by great public concern. In order to provide a target-oriented blueprint for peace and prosperity to all countries in the near future (2030), the United Nations (UN) announced 17 Sustainable SDGs on 25 December 2015 [9], reflecting the increased global awareness for the environmental issues. In this regards, the Target 12.3 of the SDGs, thus, calls for halving per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains. In line with the international trends, the Taiwan government announced the Taiwan's Sustainable Development Goals in July 2019 [10], including the goals for 2030 and targets for 2020. Regarding FLW, the 12th Goal is "Responsible Consumption and Production", which involves the Goal 12.3 by reducing food lose in the supply-chain side and also reducing food wastage in the consumer side, and the Goal 12.4 by reducing (food) waste generation through green production and also promoting (food) waste valorization and its technological capacity. In addition, the 7th and 13th Goals in the Taiwan's SDGs aims at taking actions for providing renewable energy and combating climate change, respectively, which were also relevant to the food waste issue.

According to the official definition in Taiwan, waste can be categorized into general (urban) waste and industrial waste. Under the circular economy principle, the central governing agency (i.e., Environmental Protection Administration, EPA) in Taiwan has implemented the Four-in-One Resource Recycling Plan over the past two decades [11,12], which combined the efforts by communities, recycling enterprises, local governments, and the Recycling Fund. It showed that the urban waste recycling rate has increased from about 10% in 2000 to over 56% in 2019 [13]. Regarding the kitchen waste (including waste cooking oil) management, the Taiwan EPA promulgated the regulations of governing the valorization of food waste from non-industrial (urban) and industrial sources by designating it as a mandatory recyclable waste under the authorization of the Waste Management Act (WMA) [14,15]. Furthermore, over ten items of food waste valorization (or reuse) from industrial sources have defined by the central responsible agencies under the authorization of the WMA, including the Council of Agriculture (COA), Ministry of Finance (MOF), and Ministry of Economic Affairs (MOEA) [16]. Currently, most of the industrial food waste items were reused as valuable feedstocks for animal feed, organic fertilizer, or biomass energy. Meanwhile, the EPA also provided the subsidies for local governments to establish their valorization (animal feed) programs for the prevention of African swine fever (ASF) spread because the virus can persist in the kitchen waste without high- temperature (>90 °C) cooking [15]. Moreover, the burden on municipal solid waste (MSW) incineration plants and sanitary landfills can be reduced in recent years [15].

Regarding the regulatory and promotional measures for mandatory valorization of food waste from the industrial sources, few studies were discussed previously [4,17]. Mirabella et al. [4] reviewed the valuable compounds and fuels derived from the solid and liquid waste in the food processing industry but lacked the promotion policies or regulatory measures for the food waste valorization. Naziri et al. [17] reported the valorization of the major agrifood (i.e., olive oil, wine, and rice) industrial by-products and waste from Central Macedonia in Greece for the recovery of value-added compounds (e.g., antioxidants) for food applications. As compared to other countries [18,19], the food waste valorization with high recycling rate in Taiwan may be a learnable case due to the adaptation of "zero waste and resource recycling" policy. In the previous studies [15,20], the author focused on the regulatory and promotion measures for the valorization of food waste from the non-industrial sources like residential and service sectors. Therefore, the present study will put emphasis on the promotion policies and regulatory measures for the valorization of food waste from industrial sources (hereinafter industrial food waste) in Taiwan. Therefore, the aim of this study was twofold. First, the updated data on the statistics and status of industrial food waste generation and treatment in Taiwan will be addressed in Section 3.1 to analyze the trends. Second, the promotion policies and regulatory measures for industrial food waste valorization were studied subsequently based on the joint-efforts by the central governing authorities under the authorization of the WMA. In addition, a case study was addressed to highlight the environmental and economic benefits regarding the valorization of urban food waste for the production of bioenergy by anaerobic digestion in Taiwan.

2. Data Mining

In this work, the statistical database, promotion policies, and regulatory measures, and case study relevant to industrial food waste valorization were accessed on the official yearbooks and relevant websites, which were briefly summarized below.

- Activity (statistics and status) of industrial food waste generation

According to the annual yearbook of environmental protection statistics [13], the updated data on the statistics and status of industrial food waste generation and treatment in Taiwan were analyzed in the present study.

- Promotion policies and regulatory measures for industrial food waste valorization

The information about the promotion policies and regulatory measures for industrial food waste valorization was accessed on the relevant website [16], which was built by the Ministry of Justice (MOJ).

- Case study: Production of bioenergy from the anaerobic digestion of urban food waste

An official plan for establishing biogas-to-power plants from the urban food waste was addressed to highlight the environmental and economic benefits of food waste valorization by anaerobic digestion in Taiwan [21].

3. Results and Discussion

3.1. Status of Industrial Food Waste Generation in Taiwan

According to the project ("Food Use for Social Innovation by Optimizing Waste Prevention Strategies") funded by the European Commission [22], the definition of food waste refers to "any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed". In this regards, food waste will be often generated from the retailers, consumers, and food service providers or food processing manufacturers due to the expiration, discard during the sorting operation, leftover, and other wastage reasons [23]. Figure 1 shows the categories of food waste based on its generation sources. In the present study, the industrial sources referred to the agricultural farms (e.g., s laughterhouse, hatchery, oyster farm, aquafarm, and truck farm), and animal-based or plant-based food processing plants or sites. By contrast, the non-industrial sources included the residential, commercial (e.g., office, retail, wholesale, warehouse and distribution, hotel, and restaurant), and service (e.g., hospital) and institutional (school) facilities [3].

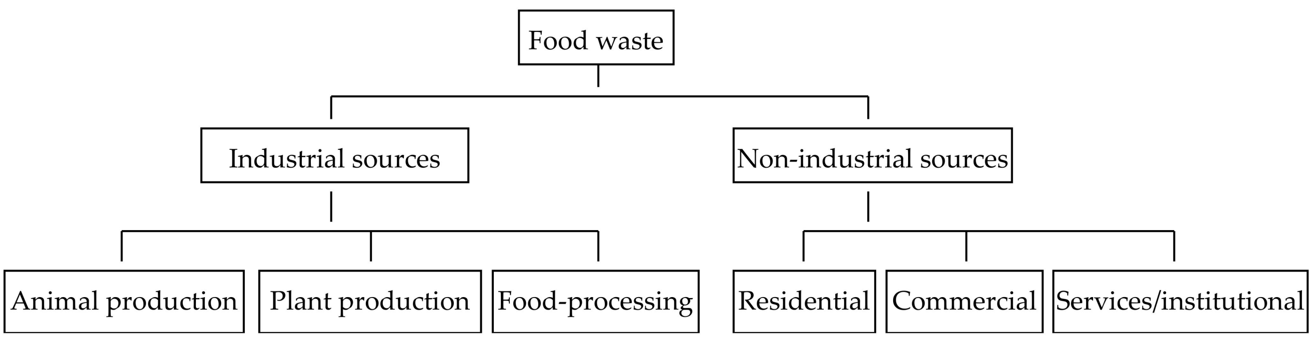

Figure 1. Food waste category and its generation sources.

In order to manage food waste from the industrial sources efficiently, the Taiwan EPA announced that the se sources with over specified amount of food waste generated annually were required to submit their industrial waste management plans by on-line reporting system based on the requirements of the WMA. According to the on-line reports during the period of 2015–2019 [24], Table 1 listed the reported amounts of industrial food waste, showing that the organic food waste from alcoholic beverage manufacturers (i.e., lees, dregs, or alcohol mash) and inorganic food waste from oyster farms (i.e., waste oyster shell) accounted for about half (about 250,000 metric ton) of industrial food waste generation in Taiwan. Table 2 showed the reported amounts of kitchen waste and waste cooking oil during the period of 2015–2019, which were categorized into the industrial sources and non-industrial sources. Obviously, the amount of kitchen waste generation was mostly from the non-industrial sources, indicating a stable amount of about 600,000 metric tons. It should be noted that the significant increases in kitchen waste generation from industrial sources and waste cooking oil from non-industrial sources in 2017 was attributed to the regulatory requirements due to the "food safety scandal" event and circular bioeconomy promotion [14,15]. It can be seen that total reported amounts of waste cooking oil significantly increased from 12,877 metric tons in 2015 to 29,507 metric tons in 2019.

Table 1. Current status of industrial food waste generation during the period of 2015–2019 [24].

Food Waste Type	Generation Amount (Metric Ton)				
	2015	2016	2017	2018	2019
Animal-based residues	19,399	26,306	30,262	36,264	46,400
Dead livestock and poultry	41,809	43,904	44,759	45,427	45,617
Fishery residues	2235	2454	2135	2049	1921
Food processing waste	31,200	31,300	31,952	32,515	14,610
Fruit and vegetable residues	26,382	25,599	26,554	28,848	22,593
Lees, dregs, or alcohol mash	149,207	152,061	139,973	142,029	127,453
Livestock and poultry slaughtering scraps	31,518	48,308	52,522	61,271	64,410
Pig hair	737	717	697	817	788
Plant-based residues	37,018	38,162	42,525	42,607	51,039
Waste oyster shell	131,196	123,966	139,068	128,574	116,352

Table 2. Current status of kitchen waste and waste cooking oil generation during the period of 2015–2019 [24].

Food Waste Type	Generation Amount (Metric Ton)				
	2015	2016	2017	2018	2019
Kitchen waste					
Industrial sources	155	1850	42,040	64,755	70,195
Non-industrial sources	609,706	575,932	551,332	594,992	498,045
Sum	609,861	577,782	593,372	659,747	568,240
Waste cooking oil					
Industrial sources	11,278	15,523	16,085	15,853	15,772
Non-industrial sources	1599	3978	12,591	12,315	13,735
Sum	12,877	19,501	28,676	28,168	29,507

3.2. Promotion Policies for the Valorization of Food Waste from Industrial Sources

Regarding the on-line reporting amount and the regulatory measures for the reuse (or valorization) status of food waste from the non-industrial (residential and commercial) sources in Taiwan, the data during the period of 2010–2017 have been addressed in the previous study [15]. Table 3 further updated the data [13], indicating that the increasing trend in composting valorization during the period of 2015–2019 could be due to the driving force by the "food safety scandal" event in September 2014 and the prevention of African swine fever (ASF) spread since 2019 [25]. Under the authorization of the WMA, the Taiwan EPA subsequently promulgated and/or revised some promotion policies for the valorization of mandatory recyclable food waste (including kitchen waste and waste cooking oil) from all sources to avoid entering the food chain and the 24 larger-scale MSW incineration plants [14]. According to the regulatory definition, the valorization (or reuse) of food waste refers to the production of value-added resources like organic fertilizer, animal feed, and biomass energy. From the regulatory joint-efforts by the central governing authorities [16], including EPA, COA, MOF, and MOEA, Tables 4 and 5 summarized the regulatory measures for the valorization (or reuse) options of urban food waste (kitchen waste and waste cooking oil) and industrial food waste, respectively.

Table 3. Amounts of urban kitchen waste in terms of recycling method over the past decade in Taiwan [1].

Year	Composting	Pig Feed	Others	Sum
2015	197,107	408,524	4076	609,706
2016	197,307	372,280	6346	575,932
2017	204,598	343,906	2828	551,332
2018	231,676	358,229	5087	594,992
2019	246,367	237,849	13,828	498,045

[1] Source [13]; Unit: metric ton.

3.2.1. Promotion Policies for the Production of Value-Added Materials from Food Waste

Over the past two decades, industrial ecology concepts, including Cradle to Cradle (C2C) and circular economy, played a prevailing role in the waste management [4]. The approach for the "zero waste" aimed at reusing the food waste as raw material (or feedstock) for new products and applications. In Taiwan, the promotion policies for the production of value-added materials from food waste were based on the legislations by the governing authorities, including the Council of Agriculture (COA), the Ministry of Economic Affairs (MOEA), and the EPA [16]. Therefore, the central governing agency (i.e., COA) jointly promulgated some regulatory measures for ensuring the bio-products from the food waste valorization under the acts, including the Fertilizer Management Act, the Feed Management Act, and the Animal Industry Act. Based on the Fertilizer Management Act, the organic fertilizer produced from food waste must meet the specifications for the soil-based nutrients/compositions like organic matter, nitrogen and phosphorus, and the limits of toxic metals, including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn).

Table 4. Regulatory measures and generation sources for urban food waste (kitchen waste and waste cooking oil) valorization under the authorization of the Waste Management Act (WMA).

Central Governing Agency (Taiwan)	Food Waste Type	Valorization Option	Generation Source
Environmental Protection Administration (EPA)	Kitchen waste	- Feed - Feedstock for feed - Feedstock for organic fertilizer - Feedstock for cultivation medium (soil) - Feedstock or fuel for renewable (biomass) energy	Residential, commercial and industrial sources
	Waste cooking oil	- Feed for soap - Feedstock for stearic acid - Feedstock for biodiesel - Feedstock for fatty acid methyl ester (blending with fuel oil) - Feedstock or fuel for renewable (biomass) energy	Residential, commercial and industrial sources

Table 5. Regulatory measures and generation sources for industrial Food waste valorization under the authorization of the WMA.

Central Governing Agency (Taiwan)	Food Waste Type	Valorization Option	Generation Source
Council of Agriculture (COA)	Waste oyster shell	- Feedstock for (mineral supplement) feed (after crushing) - Feedstock for fertilizer (after crushing)	Oyster farm
	Fruit and vegetable residues	- Feedstock for organic fertilizer - Edible directly for livestock and poultry	Fruit and vegetable wholesale market
	Pig hair	- Feedstock for feed - (Not to be used as feed ingredients for ruminants) - Feedstock for organic fertilizer - Pig hair product	Slaughterhouse
	Livestock and poultry slaughtering scraps	- Feedstock for feed - (Not to be used as feed ingredients for ruminants) - Feedstock for organic fertilizer - Feedstock or fuel for biomass energy	Slaughterhouse
	Dead livestock and poultry	- Feedstock for feed - (Not to be used as feed ingredients for ruminants) - Feedstock for organic fertilizer - Feedstock or fuel for biomass energy	Animal farm, breeder, meat wholesale market, or slaughterhouse
	Broken eggs or hatching waste	- Feedstock for organic fertilizer	Animal farm, egg washing field, egg (washing) warehouse, hatchery, breeding poultry production site
Ministry of Finance (MOF)	Lees, dregs, or alcohol mash	- Feed - Feedstock for feed - Feedstock for organic fertilizer - Feedstock for organic cultivation medium	Alcoholic beverage manufacturer
Ministry of Economic Affairs (MOEA)	Plant-based residues	- Feed - Feedstock for feed - Feedstock for organic fertilizer - Feedstock for organic cultivation medium - Feedstock for biomass energy	Food & drinking manufacturer
	Animal-based residues	- Feed - (Not to be used as feed ingredients for ruminants) - Feedstock for feed - Feedstock for organic fertilizer - Feedstock for organic cultivation medium - Feedstock for biomass energy	Food manufacturer

3.2.2. Promotion Policies for the Production of Bioenergy from Food Waste

Due to its richness in moisture, carbohydrate polymers and other constituents (e.g., protein, and lipids), food waste has been used as an excellent feedstock for the production of various kinds of value-added biobased materials and/or biobased products via microbial conversion, including methane, hydrogen, ethanol, organic acids, and bio-fertilizers [26,27]. More importantly, the production of bioenergy from food waste would not only solve the environmental hazards from the MSW incineration plants and sanitary landfill sites but will also mitigate the emissions of greenhouse gases while replacing the usage of fossil fuels by bioenergy. In Taiwan, the promotion policy for the production of bioenergy from food waste was based on the legislation of the Renewable Energy Development Act (REDA) in 2009, which was recently revised in 2019. Among the promotion measures in the REDA, the central governing agency (i.e., MOEA) shall announce the so-called feed-in tariff (FIT) rates for all types of renewable energy annually, which were reviewed or amended in considering related factors like technical progress in power generation, changes in cost and renewable electricity goal achievement. Table 6 listed the FIT rates for promoting electricity generation from biomass-to-power (via anaerobic digestion process or not) and waste-to-power in Taiwan since 2010. It showed an increasing trend from 2.0615 NT$/kW-h in 2010 to 5.1176 NT$/kW-h in 2021 for the biomass-to-power by anaerobic digestion. The

MOEA will open up the business model for the direct supply and transfer of green power generation, and also guarantee the fixed 20-year rate which renewable electricity can be converted at the feed-in tariff (FIT) officially announced.

Table 6. Variations of feed-in tariff (FIT) for biomass-to-power and waste-to-power in Taiwan since 2010.

Year	FIT (NT$/kW-h) [a]		
	Biomass-to-Power by AD	Biomass-to-Power by Non-AD	Waste-to-Power
2010	2.0615	2.0615	2.00879
2011	2.1821	2.1821	2.6875
2012	2.6995	2.3302	2.8240
2013	2.8014	2.4652	2.8240
2014	3.2511	2.5053	2.8240
2015	3.3803	2.6338	2.8240
2016	3.9211	2.7174	2.9439
2017	5.0087	2.6000	3.9839
2018	5.0161	2.5765	3.8945
2019	5.0874	2.5765	3.8945
2020	5.1176	2.6871	3.9482
2021	5.1176	2.6884	3.9482

[a] 1 NT$ ≈ 0.035 US$ (2020).

In order to diversify food waste treatment options and also reduce the burdens on the MSW incineration plants and sanitary landfills in Taiwan, the EPA revised the relevant regulation (“Regulations for Collection, Clean-up and Treatment of General Waste”) on 3 November 2017 and announced the new regulation (“Management Regulations for Reuse of Common Industrial Waste”) on 8 January 2018. The former regulation added the energy recovery of food waste and other organic residues to one of the specified treatment methods. The food waste and waste cooking oil were listed for the industrial waste reuse items in the latter regulation. Their reuse options have been listed in Table 4. Afterwards, the EPA further launched the Resource Recycling and Reuse Plan in 2018, which was based on the cross-departmental action strategies and promotion measures under the Taiwan’s SDGs [10]. In this regards, the EPA has assisted five municipal governments to build food waste bioenergy plants since 2018, which will be further addressed as a case study to discuss their environmental and economic benefits in the subsequent section.

3.3. Official Plan for the Production of Bioenergy from the Anaerobic Digestion of Urban Food Waste

In Taiwan, industrial waste refers to waste that is generated from industrial activities (or sources), but excludes waste generated by the employees themselves. In this regards, food waste (e.g., kitchen waste and waste cooking oil) derived from industrial sources can be listed as general (urban) waste. In order to reduce the negative impacts of food waste on MSW incineration plants and/or sanitary landfills, the Taiwan EPA has been funding local governments in developing diverse treatment options to increase the food waste processing capacity. For instance, the EPA has subsidized the installation of over 50 sets of food waste pretreatment (i.e., shredding and drying) composting plants since 2003. In recent years, the EPA is subsidizing the establishments of food waste-to-bioenergy plant in the five special municipalities, including Taichung City, Taoyuan City, Taipei City, New Taipei City, and Kaohsiung City [21]. Table 7 listed the comparisons of five municipalities in Taiwan, showing that the variations of food waste generated per capita in 2019 were very large. Among these biogas-to-power plants, the first case in Taichung City has been completed and was in operation because this site was to revitalize the old composting plant. Taoyuan City planned to finish the construction of its plant by the end of July 2021, and all plants were estimated to be completed by 2024. Upon completion, these plants can process 230,000 metric tons of food waste per year for about 14.5 million citizens and also generate 41,970,000 kW-h electricity per year. The expected power generation not only gains an annual revenue of NT$214.79 million from selling electricity based on the FIT rate of 5.1176 NT$/kW-h, but also reduces the emissions of carbon dioxide by 21,363 metric tons according to the official carbon emission factor of 0.509 kg CO_2/kW-h [28].

Table 7. Comparisons of five municipalities in Taiwan.

Item	Taipei City	Kaohsiung City	New Taipei City	Taichung City	Taoyuan City
Area (km^2)	271.8	2951.9	2053.6	2214.9	1221.0
Population (Million)	2.61	2.77	4.03	2.82	2.26
Year of establishment	1967	1979	2010	2010	2014
District	12	28	29	29	13
Food waste generation [1] (metric ton)	61,849	30,319	124,178	41,147	34,308
Amount of food waste generated per capita (kg/capita)	23.7	10.9	30.8	14.6	15.2

[1] Source [13].

4. Conclusions

In Taiwan, industrial food waste was listed as one of "mandatory" recyclables under the authorization of the WMA for the production of biobased products like organic fertilizer, animal feed, and bioenergy (or biogas). This circular bioeconomy option would not only solve the environmental hazards from the traditional treatment options but will also mitigate the emissions of greenhouse gases while replacing the usage of fossil fuels by biobased materials and bioenergy. In this work, the findings showed that the organic food waste from alcoholic beverage manufacturers (i.e., lees, dregs, or alcohol mash) and inorganic food waste from oyster farms (i.e., waste oyster shell) accounted for about half (about 250,000 metric ton) of industrial food waste generation in Taiwan during the period of 2015–2019. Under the jointly efforts and legislations by the central governing agencies (i.e., EPA, COA, and MOEA), current regulatory and technological measures for converting industrial food waste into organic fertilizers, animal feed, biofuels, or electricity have resulted in the significant benefits from the environmental and economic viewpoints. In order to achieve the Taiwan's SDGs, one of official plans was to build five large-scale bioenergy plants at local governments via anaerobic digestion of food waste, which were estimated to process 230,000 metric tons annually and also generate 41,970,000 kW-h electricity per year. On completion by 2024, the expected power generation not only gains an annual revenue of NT$214.79 million from selling electricity based on the FIT rate of 5.1176 NT$/kW-h, but also reduces the emissions of carbon dioxide by 21,363 metric tons according to the official carbon emission factor of 0.509 kg CO_2/kW-h. Obviously, the regulatory measures for industrial food waste valorization in Taiwan play a critical role in providing environmental, economic and energy benefits, which will be more adopted in industries.

Author Contributions: Conceptualization, W.-T.T.; methodology, Y.-Q.L.; validation, Y.-Q.L.; data curation, Y.-Q.L.; formal analysis, Y.-Q.L.; writing—original draft preparation, W.-T.T.; writing—review and editing, W.-T.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ishangulyyev, R.; Kim, S.; Lee, S.H. Understanding food loss and waste—Why are we losing and wasting food? *Foods* **2019**, *8*, 297. [CrossRef] [PubMed]
2. Mak, T.M.W.; Xiong, X.; Tsang, D.C.W.; Yu, I.K.M.; Poon, C.S. Sustainable food waste management towards circular bioeconomy: Policy review, limitations and opportunities. *Bioresour. Technol.* **2020**, *297*, 122–497. [CrossRef] [PubMed]
3. Rhyner, C.R.; Schwartz, L.J.; Wenger, R.B.; Kohrell, M.G. *Waste Management and Resource Recovery*; CRC Press: Boca Raton, FL, USA, 1995; pp. 26–39.
4. Mirabella, N.; Castellani, V.; Sala, S. Current options for the valorization of food manufacturing waste: A review. *J. Clean. Prod.* **2014**, *65*, 28–41. [CrossRef]
5. Capone, R.; Berjan, S.; El Bilali, H.; Debs, P.; Allahyari, M.S. Environmental implications of global food loss and waste with a glimpse on the Mediterranean region. *Int. Food Res. J.* **2000**, *27*, 988–1000.
6. Carmona-Cabello, M.; Garcia, I.L.; Leiva-Candia, D.; Dorado, M.P. Valorization of food waste based on its composition through the concept of biorefinery. *Curr. Opin. Green Sustain. Chem.* **2018**, *14*, 67–79. [CrossRef]
7. Nayak, A.; Bhushan, B. An overview of the recent trends on the waste valorization techniques for food wastes. *J. Environ. Manag.* **2019**, *233*, 352–370. [CrossRef] [PubMed]
8. Caldeira, C.; Vlysidis, A.; Fiore, G.; De Laurentiis, V.; Vignali, G.; Sala, S. Sustainability of food waste biorefinery: A review on valorisation pathways, techno-economic constraints, and environmental assessment. *Bioresour. Technol.* **2020**, *312*, 123–575. [CrossRef] [PubMed]
9. United Nations (UN). Take Action for The Sustainable Development Goals. Available online: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed on 24 February 2021).
10. Council for Sustainable Development. *Annual Review Report on the Taiwan's Sustainable Development Goals*; Environmental Protection Administration: Taipei, Taiwan, 2020. (In Chinese)
11. Tsai, W.T.; Chou, Y.H.; Lin, C.M.; Hsu, H.C.; Lin, K.Y.; Chiu, C.S. Perspectives on resource recycling from municipal solid waste in Taiwan. *Resour. Policy* **2007**, *32*, 69–79. [CrossRef]
12. Chang, Y.M.; Liu, C.C.; Hung, C.Y.; Hu, A.; Chen, S.S. Change in MSW characteristics under recent strategies in Taiwan. *Waste Manag.* **2008**, *28*, 2443–2455. [CrossRef] [PubMed]
13. Environmental Protection Administration (EPA, Taiwan). *Yearbook of Environmental Protection Statistics 2019*; EPA: Taipei, Taiwan, 2020.
14. Tsai, W.T. Mandatory recycling of waste cooking oil from residential and commercial sectors in Taiwan. *Resources* **2019**, *8*, 38. [CrossRef]
15. Tsai, W.T. Turning food waste into value-added resources: Current status and regulatory promotion in Taiwan. *Resources* **2020**, *9*, 53. [CrossRef]
16. Laws and Regulation Retrieving System (Taiwan). Available online: https://law.moj.gov.tw/Eng/index.aspx (accessed on 23 February 2021).
17. Naziri, E.; Nenadis, N.; Mantzouridou, F.T.; Tsimidou, M.Z. Valorization of the major agrifood industrial by-products and waste from Central Macedonia (Greece) for the recovery of compounds for food applications. *Food Res. Int.* **2014**, *65*, 350–358. [CrossRef]
18. Ju, M.; Bae, S.J.; Kim, J.Y.; Lee, D.H. Solid recovery rate of food waste recycling in South Korea. *J. Mater. Cycles Waste Manag.* **2016**, *18*, 419–426. [CrossRef]
19. Lim, W.J.; Chin, N.L.; Yusof, A.Y.; Yahya, A.; Tee, T.P. Food waste handling in Malaysia and comparison with other Asian countries. *Int. Food Res. J.* **2016**, *23*, S1–S6.
20. Tsai, W.T. Management considerations and environmental benefit analysis for turning food garbage into agricultural resources. *Bioresour. Technol.* **2008**, *99*, 5309–5316. [CrossRef] [PubMed]
21. Taiwan's Renewable Energy News (Ministry of Economic Affairs, Taiwan). Available online: https://www.re.org.tw/news/more.aspx?cid=198&id=3126 (accessed on 27 February 2021).
22. Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS) Website (EU). Available online: https://www.eu-fusions.org/index.php (accessed on 26 February 2021).
23. Food Lose and Food Waste (FAO). Available online: http://www.fao.org/food-loss-and-food-waste/flw-data (accessed on 26 February 2021).
24. Industrial Waste Reporting and Management Information System (Taiwan EPA). Available online: https://waste.epa.gov.tw/RWD/Statistics/?page=Month1 (accessed on 28 February 2021).
25. Wang, W.H.; Lin, C.Y.; Ishcol, M.R.C.; Urbina, A.N.; Assavalapsakul, W.; Thitithanyanont, A.; Lu, P.L.; Chen, Y.H.; Wang, S.F. Detection of African swine fever virus in pork products brought to Taiwan by travelers. *Emerg. Microbes Infect.* **2019**, *8*, 100–102. [CrossRef] [PubMed]
26. Kiran, E.U.; Trzcinski, A.P.; Ng, W.J.; Liu, Y. Bioconversion of food waste to energy: A review. *Fuel* **2014**, *134*, 389–399. [CrossRef]
27. Sen, B.; Aravind, J.; Kanmani, P.; Lay, C.H. State of the art and future concept of food waste fermentation to bioenergy. *Renew. Sustain. Energy Rev.* **2016**, *53*, 547–557. [CrossRef]
28. Ministry of Economic Affairs (MOEA). *Energy Statistics Handbook–2019*; MOEA: Taipei, Taiwan, 2020.