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Recycling 2020- Cost and revenue analysis for energy recycling of agricultural waste in Taiwan- Esher Hsu- National Taipei University

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Introduction:
Agricultural waste contains farming waste and livestock waste. In Taiwan, most farming waste is reused or dumped in farm site without efficiently recycled. Most livestock waste is recycled by composting or fermented for farming to improve soil fertility. Current energy recycling of livestock waste is mainly on biogas power generation. The energy recycling of agricultural waste is regulated by three major ministries in Taiwan. If the three departments are not effectively coordinated, the efficiency of energy recycling would be reduced. Therefore, energy recycling of the agricultural waste has been argued for years in Taiwan.

Due to the potential of agricultural waste to develop biomass energy, in response to the promotion of renewable energy and the horizontal linkage of relevant regulations, Taiwan's Agricultural Waste Recycling Management Measures were amended in 2017. The amended recycling management measures lists additional six agricultural wastes (livestock manure, mushroom cultivation waste, livestock slaughtered waste and carcasses, fruit and vegetable residues, flower residues and cultivation media) for renewable energy raw materials or fuel. However, the agricultural waste used for renewable energy raw materials or fuel has to comply with the Renewable Energy Development Regulations. The amended regulations not only increase the flexibility of using agricultural waste, but also encourage the energy recycling of agricultural waste in Taiwan. Besides, the Feed-in tariffs (FITs) of biomass energy with anaerobic digestion facilities were increased around twice from 2016 to 2018.

It is expected that the amended recycling management measures and promotion policies would provide a convenient environment for cooperative companies between agricultural industry and other industries to develop biomass energy which may also improve the development efficiency of biomass energy as well. This paper intends to evaluate the feasibility of energy recycling of agricultural waste in Taiwan based on a cost-revenue analysis under current regulations, and further provides policy suggestions for energy recycling of agricultural waste.

Keywords: Agricultural waste; Biomass energy; Energy recovery; Cost-revenue analysis; FITs.

Cost and revenue of energy recycling of agricultural waste:
Due to policy promotion and increasing recycling awareness, more and more farms intend to recycle agricultural waste instead of sending them to incineration or landfill. In 2018, the revision of the management measures for the recycling of agricultural wastes, coupled with the promotion of renewable energy policies, has led to a rapid increase in the number of farmers who develop biomass energy. The sources of waste for biogas power generation are mainly from pig manure, chicken manure and cow dung. Since biogas power generation varies depending on the farm size and the equipment of biogas power generation, it is estimated that the average annual power generation of livestock waste is about 20kWh/pig, 4.02kWh/chicken, and 83.33kWh/cow. The generated biogas power is mainly used on farm site. At present, most farms use self-produced electricity, and sell the surplus electricity to Tai power.

A chicken farm uses generated chicken manure as input material for its biogas plant. The power generating cost is around NT$7.7/kWh, but it can only receive FITs for NT$3.9211/kWh (contract in 2016 FITs). The cost is much higher than the revenue for the biogas plant. Although the FITs have been increased to NT$5.0161/kWh in 2018, around two-thirds of the cost, the revenue from biogas power generation is still lower than the cost. Besides, small farming scale of livestock industry in Taiwan also leads to a lower efficiency of biogas energy recovery. The high investment costs of biogas power generation equipment and relatively low of the grid-connected electricity price (FITs) could not provide investment incentives for energy recycling of agricultural waste which thus reduces recovery efficiency of Taiwan's waste energy recycling. If the manure of pigs, cows, and chickens can be collected to a biogas power plant or a common processing center operated by an independent industry or a combination of different industries, the operating cost could be reduced and further increase benefit.

The agricultural waste including farming waste and livestock waste is collected by the composting industry without charge. Therefore, the compost recycling has relatively low cost but the quality of compost is unstable for fertilizer use, thus reducing the revenue of composting. Currently, most farming waste was directly reused in farm site or recovered by composting and only few of it was energy recovered to get fuel or biogas. According to the amended recycling management measures, in addition to livestock waste, farming waste including fruit and vegetable residues, flower residues and cultivation media could be used for input materials to generate renewable energy. It is expected energy recycling of farming waste would be increased. The biogas plants could mix livestock waste with farming waste as input to reduce the operating cost.

Conclusion

This work is partly presented at 12th World Congress and Expo on Recycling on April 20-21, 2020 at Rome, Italy

The study results show that the cost of energy recovery of agricultural waste is about twice of the revenue for biogas power plant in Taiwan, which could not provide investment incentives for energy recycling of agricultural waste. Moreover, the small farming scale of agricultural sector also limits the development of energy recycling. In order to make the recycling more efficient and more environment-friendly, study results suggest that develop a differentiated FITs for biogas power based upon the portion of input used (manure, slurry, and cropping residue) and the scale of the biogas plant to promote energy recycling of agricultural waste, encourage cooperation among different agricultural industries or with other industries to build up common processing centers for biomass energy recycling through subsidy.