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Cleaner Production Implementation at Chicken Slaughtering Plant

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Abstract

Moving towards becoming a developed and high income nation by 2020, industrialisation in Malaysia has been expanding rapidly. However, an industrialisation process that do not consider sustainable development would significantly increase the risks to safety, health and environment. Therefore, Cleaner Production (CP) provides an assessment of production processes and aims to reduce the negative impact to safety, health and environment and at the same time increase the productivity of the company. This paper aims to investigate the carbon dioxide emission from the chicken slaughtering industry by focusing on five parameters namely the fuel consumption, electricity consumption, water consumption, wastewater generation and solid waste generation. The methodology used to achieve the objective includes direct observation, review of relevant documents and on-site inspection. It is found that among the five parameters, the highest contribution of carbon dioxide emission comes from the electricity consumption. CP options were suggested to the company to help reduce the electricity consumption but are still subjected to the feasibility studies.

Keywords: Cleaner production; green industry; chicken slaughtering plant

1.0 INTRODUCTION

1.1 Cleaner Production

The concept introduced by CP focuses on the pollution prevention rather than the end

of pipe pollution control. The concept can be implemented in all sectors of the industry be it large or small. It is a direct activity towards optimisation of the production process. The implementation has to include the resource and process efficiency, which is a key factor of the transition towards a Green Industry and Green Economy. The term CP is defined by the United Nations Environment Programmes (UNEP) in 1990 as "the continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment". This term is widely used for all the programs that are linked with the CP advancement and it remains legal [1].

CP requires a change in attitude, responsible environmental management and an evaluation of technology options. It is a specific progress to advance production processes which includes conserving raw materials and energy, eliminating toxic raw materials and reducing the amount of all toxic emissions and wastes before it is discharged. In addition, it also works to improve the products by focusing on reducing negative impacts along the entire life cycle of the product, from the raw material extraction to the ultimate disposal of the product. To improve the services, it incorporates the environmental concerns in designing and delivering services.

CP implementation is possible to enhance economic growth in industries all over the world by reducing the water, energy, and raw materials resulting in the reduction of environmental footprint[2]. In fact, by reducing emissions, less waste will be generated and the cost saved can be further spent to improve systems of recycling and waste management[3]. To achieve these objectives, few CP strategies are highlighted such as good housekeeping, input substitution, better process control, equipment modification, technology change, product modification and on-site recovery/reuse [4].

1.2 CP Implementation in Malaysia and Related Issues

In Malaysia, a few successful cases of CP implementation are associated with reduction of water or energy consumption in industry. A study has found that a fish filleting plant that introduced a new process system managed to improve its productivity, reduce electricity usage in the drying and collection of offal, have more water saving opportunities and reduce silage production from offal. As a result, the processing of fish fillet has become much cleaner than a fish meal (almost zero waste) and solved the pollution problem that previously bothered its neighbours and disrupted the environment with the fish meal plant[5]. Another case study conducted by the Department of Environment Malaysia has found that in In'Joy Marketing (M) Sdn. Bhd., a food industry, has achieved a saving of23% of fuel oil used that consequently reduced the energy consumption. In addition, the productivity has improved by 60% attributed to the increase in production from 5 to 8 batches per 8 hour shifts[6].

However, besides the benefits that CP offers and the successful case studies, there are still constraints for the CP implementation. A study has found that spatial limitation, high cost, lack of awareness and knowledge of available technologies as well as inadequate waste management skills[7] becomes the limitation for the industry. Apart from that, with no specific legal requirement in the Environmental Quality Act 1974 for CP implementation in Malaysia has also restricted CP implementation.

One of the main environmental concern in the chicken slaughtering industry is the amount of untreated wastewater that contains high levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) that mainly generated during the washing process. Based on the Environmental Quality Report 2014, the BOD loading in 2014 is about 762 ton per day which has increased 0.5% from 2013. Even though the main contributor is still the sewage system, the food processing industry still contributes 27% of the total daily BOD loading, just behind the sewage system and agricultural sector [8]. This is due to the absence of on-site industrial effluent treatment, poor maintenance of treatment system and insufficient treatment capacity.

2.0 METHODOLOGY

The data was collected for five weeks at a chicken slaughtering factory in Merlimau through direct observation, review of relevant documents, detailed audit as well as on-site measurements. First, a preliminary site visit was conducted at the plant to obtain the background information on the company and its process flowchart. Itis important in order to understand the production process, unit operation, onsite facilities and other activities in plant. Then, a walkthrough assessment were conducted to identify related issues and activities that can be further assessed during the detailed audit.

A detailed audit was conducted to obtain the qualitative and quantitative information for the entire process in order to calculate the five carbon dioxide emission entities, namely the fuel consumption, electricity consumption, water consumption, wastewater generation and solid waste generation. To calculate the carbon dioxide emission from utilised resources and waste produced, a carbon dioxide emission factor shown in Table 1 [9], and equation (1) as well as equation (2), provided by the Inter-governmental Panel on Climate Change[10] were used.

$$CO_2e(kgCO_2) = CEF\left(\frac{kgCO_2}{unit\ entity}\right) \times entity\ utilisation\ or\ rate\ (unit\ entity) \quad (1)$$

$$CO_2e(kgCO_2) = CEF\left(\frac{kgCO_2}{unit\ entity}\right) \times entity\ generation\ or\ rate\ (unit\ entity) \quad (2)$$

Table 1: Basic Carbon dioxide Emission Factor (CEF) Value

Resources utilised /Waste produced	**CEF**	**Unit**
Water	0.8	kg CO_2/m^3
Electricity	0.67	kg CO_2/kW.hr
Fuel-diesel	1.80	kg CO_2/liter
Solid waste	3.7	kg CO_2/kg
Wastewater	1	kg CO_2/kg COD removed

The information is critical to generate CP options for the reduction of carbon dioxide emission and overall production cost. Based on the options generated, it is important to perform the environment and economic feasibility study in order to identify and prioritize the most feasible and beneficial option [11].

3.0 RESULTS AND DISCUSSION

3.1 Observation of Overall Process

Figure 1, Figure 2 and Figure 3 show the overall processes in the slaughtering factory beginning from the initial stage where the chickens arrive at the factory until the packaging and further processes (to make chicken nugget and chicken sausage product). The receiving process starts at 6.00 a.m. where the plant will receive live chickens from the supplier. Then, the chicken will be calmed down in the lorry after the trip for 30 minutes using a fan. This process allows the chickens to be ready for slaughtering session.

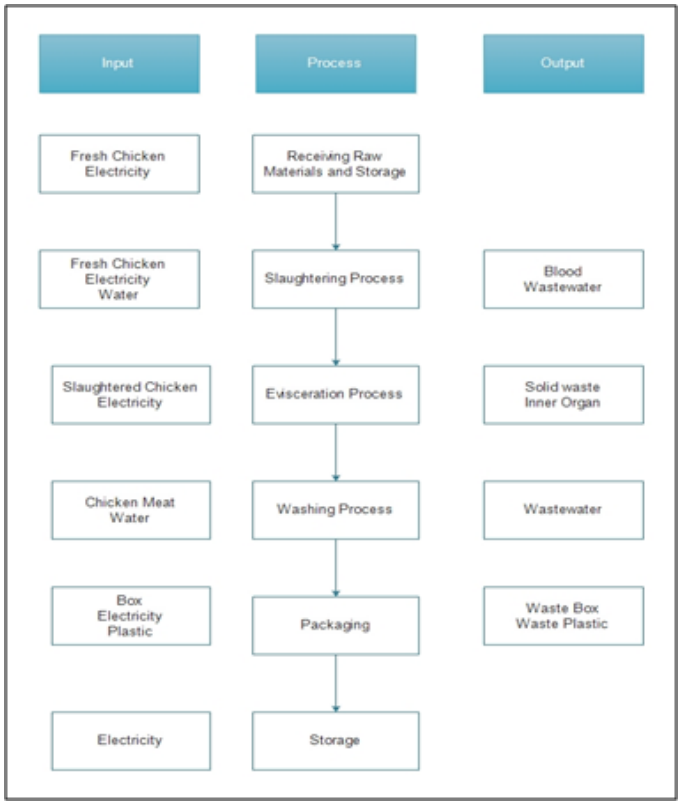

Figure 1: Chicken Slaughtering Process

Live chickens will then be stacked on the conveyor (hanging position). Throughout the assembling or stacking process, the workers should make sure that the chickens are still alive when they hang them. Then, the chickens will go through a stunning process that involves two steps, in which the chickens will be soaked in water to make them wet and then will go to the stunning machine. This stunning machine will make the chickens to be static so that the slaughtering process can be done smoothly.

After that, the chickens will proceed to the slaughtering process. The workers inside the slaughtering room must have a certificate of halal slaughtering from Halal Malaysia. This is the important part where the chickens should be handled in a halal

manner and they eventually be checked by the Halal Malaysia officer. Then, the chickens will go to the bleeding room where the slaughtered chickens will stay at this room for 4 to 5 minute to completely bleed.

Next, the chickens will be soaked in the scalding tank with a water temperature of around 58 °C to 60 °C. This process allows the chickens' feathers to be easily removed in the next process. After that, the chickens will go through the de-feathering machine to remove their feathers. After the chickens' feather are removed, the chickens will proceed with evisceration process at the evisceration area. This is the process that allows the chickens to be completely cleaned from blood, intestines and parts of the chickens that maybe infected. This process also allows the side products to be processed such as the head, feet, gizzard and chicken's liver to meet specific demands from a subset of customers.

Next is the final bird washing process for the chickens to be fully cleaned before they are sent to the chilling area. Then, the chickens are chilled in the chilling area. This chilling area allows for instant cooling for the chicken in order to maintain the quality of the chicken throughout the later processes. The chickens will then be transferred to the deboning and packaging area. In this area, the chickens will be divided into three groups for full packaging, special part packaging and further stock. For each part, there are a certain specifications that needs to be met following requirements from the customers. Next, the chickens from all three groups will be transferred to different cold rooms, different storages or directly to the distribution area for delivery to customers.

The further process is the process of making chicken nuggets and chicken sausages. Initial processes for this further processing includes the chicken meat (boneless) processing, ingredients preparation and processing, mixing and stuffing. After these initial processes are done, the further processes for chicken nugget and chicken sausage will be done separately. For the chicken nuggets manufacturing, the process will proceed with the frying process using a frying machine. Then, the chicken nuggets will be moved to the freezing machine using a specific conveyor. After the chicken nuggets refrozen to a temperature about below 0 °C, the chicken nuggets are ready for packaging. Afterwards, the chicken nuggets will be transferred to storage and are ready for distribution to customers.

The chicken sausages process also proceeds after the initial processes are done. The chicken sausages are then ready to proceed with smocking and cooking process at a temperature of about 75 °C to 80 °C. After the chicken sausages are well-cooked, they will be cooled down to room temperature with help of showering process to speed up the cooling process. Then, the chicken sausages are ready for the next process which is the peeling process. This peeling process is the process that peels off the stuffing plastics that forms the chicken sausage shape (original size chicken sausage or mini chicken sausage). After the peeling process, the chicken sausages will proceed to the packing process and will be ready to be transferred by conveyor to the freezing machine. After the chicken sausages are cold enough at a temperature below 0°C, the chicken sausages will now be ready for packaging before finally transferred to storage. The chicken sausages are then ready to be distributed to the customers.

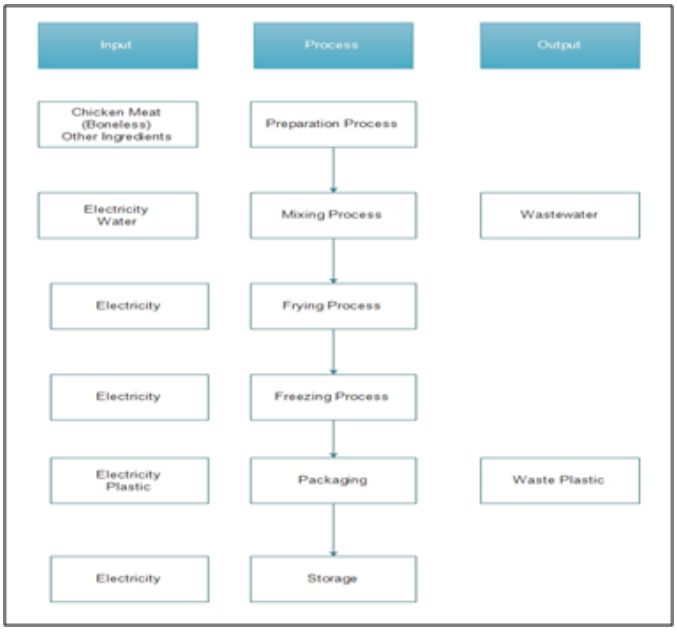

Figure 2: Chicken Nugget Processing Flowchart

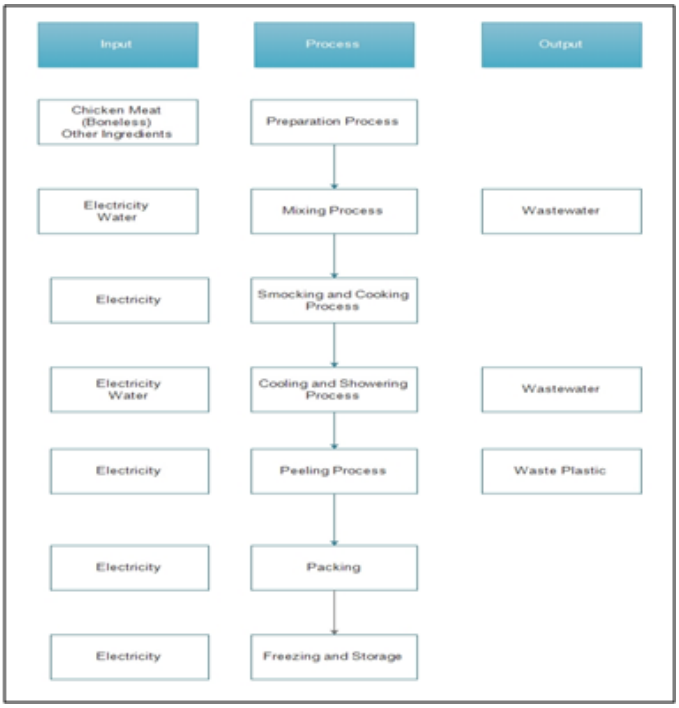

Figure 3: Chicken Sausage Processing Flowchart

3.2 Amount of Resource Utilized and Waste Produced

From the detailed audit conducted at the plant, a summary of resource consumption

and waste produced is shown in Table 1. The main use of waster is for slaughtering and washing process. Only 5% is used in cleaning and about 2% is used for domestic purposes. The water is purchased from Syarikat Air Melaka Berhad at RM2.15 per $1m^3$, resulting in a total water consumption cost of RM 90,300.00 per month.
Fuel (diesel) is used in the boiler to generate steam for the slaughtering process and sausage processing. The amount of fuel used is about 18,000 litres per month. Electricity is the largest amount of resources used in this plant amounting to 2,157,000 kWh per month. The main use of electricity is for the operation of the compressor which functions to maintain the storage room at below -4^0C.
Subsequently, the whole process produces about 12,480,000 litres of wastewater and 212,000 kg of solid waste per month. The wastewater is treated in the industrial effluent treatment system before it is discharged to the nearby river. The solid waste is mainly generated from the de-feathering process, evisceration process and packaging process.

Table 1: Resource Consumption and Waste Produced

Resources utilised /Waste produced	**Amount**
Water consumption	42,000 m^3/month
Fuel consumption	18,000 litter/month
Electricity consumption	2,157,000 kWh/month
Wastewater generation	12,480,000 litter/month
Solid waste generation	212,000 kg/month

3.3 Carbon dioxide Emission Analysis

Figure 4 elucidates that the highest carbon dioxide emission comes from the electricity consumption while the lowest is from wastewater generation.

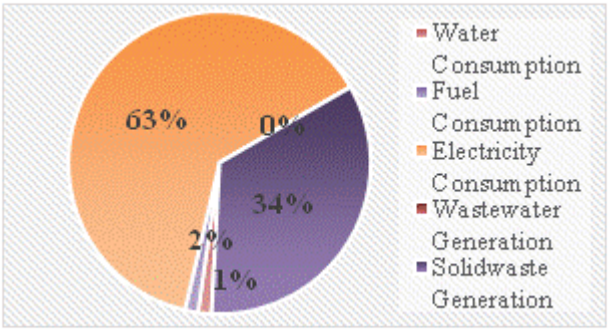

Figure 4: Percentage of Carbon dioxide Emission from Chicken Slaughtering Plant

The total amount of carbon dioxide emission from the chicken processing plant is 2,296,151.60 kg in which the highest contribution is from the electricity consumption, followed by solid waste generation, water consumption, fuel consumption and

wastewater generation. Further assessment on electricity consumption has found that seven unit operations namely the (1) ammonia compressor for cold room, (2) motors at feet cutting machines, (3) pumps at evisceration department, (4) cutter machines at evisceration department, (5) pumps at debone department, (6) water chiller motors at debone department and (7) motors for meat maker machine contribute to the high electricity consumption.

3.4 CP Options and Feasibility Analysis for Reduction of Electricity Consumption

The implementation of CP options at ammonia compressor room could contribute to significant reduction in carbon dioxide emission as well as provide saving for the company. This is because out of the total electricity consumption in the plant, the electricity use for the compressor alone is about 1,558,552.32 kWh per month which is equal to 72% of the total electricity consumption.

Therefore, this study proposes three CP options to reduce the electricity consumption. First, the company has to reduce the time taken for the entry of the product to the cold room. Second, the company has to reduce the number of door openings for the cold room, which can reduce the electricity consumption by reducing the heat loss to the environment. Moreover, it can increase the productivity by reducing the contamination coming from the opening and closing of the cold room door. However, this option requires attitude changing among the worker in the company. Finally, this study proposes for the industry to install an inverter for the compressor. However, the installation of the inverter would incur an additional cost for the company.

The economic feasibility study shows that the company can save up to RM 27, 275.00 per month along with a reduction of 77,928 kWh electricity usage per month. There would also be an immediate return of investment from the implementation of the first and second suggestions. However, with the installation of an inverter to the compressor, the company can save up to RM 54, 550.00 per month with an electricity use reduction of 155,855 kWh per month and the return of investment estimated to be in 1.5 months.

4.0 CONCLUSION

Based on this study, the highest carbon dioxide emission comes from electricity consumption due to the fact that this industry requires cold rooms for product storage. It is suggested that the company reduce the frequency of opening of the cold room doors thus reducing the compressor operation.

Acknowledgment

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