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CLEANER PRODUCTION IMPLEMENTATION AT CHICKEN SLAUGHTERING PLANT

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ABSTRACT

Moving towards developed and high income nation by 2020, the pace of industrialisation in Malaysia has been increasing rapidly. On the other side of the spectrum, industrialisation process that is not considering the sustainable development would significantly increase the risk to safety, health and environment. Therefore, Cleaner Production (CP) provides an assessment of production process that aim to reduce the impact to safety, health and environment as well as increase the productivity of the company. This paper aims to investigate the carbon dioxides emission from the chicken slaughtering industry by focusing into five entities namely fuel consumption, electricity consumption, water consumption, wastewater generation and solid waste generation. The methodology used to achieve the objective are direct observation, reviewing relevant documents and on site measurement. It is found that among the five entities, the highest contribution of carbon dioxide emission is from the electricity consumption. CP options were suggested to the company to reduce the electricity consumption and subjected to the feasibility study in the future.

Keywords: cleaner production, green industry, chicken slaughtering plant.

INTRODUCTION

Cleaner production

The concept introduced by CP is moving towards the pollution prevention rather than end of pipe pollution control. The concept can be implemented in all sectors within small or large scale industries. It is a direct activity towards optimisation of production process. The implementation has to include the resource and process efficiency, which is a key factor of the transitions towards the Green Industry and Green Economy. The term CP was defined by 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 linked with CP advancement and it remains legal (The United Nation Environmental Program, 2001).

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

CP is possible to enhance economic growth in industries all over the world by reducing the water, energy, raw materials resulting in the reduction of environmental footprint (Jegannathan *et al*., 2011). In fact, by reducing emissions, less waste and cost savings can be derived to improved systems of recycling and waste management (Dovi *et al*., 2009). 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 (Staniškis, 2011).

CP implementation in Malaysia and issues related

In Malaysia, a few successful cases of CP implementation were associated with reduction of water or energy consumption in industry. Study has found that in fish filleting plant which by introducing new process system, it can improve the productivity, reducing electricity in drying the collection of offal, water saving opportunities and reducing silage production from offal. As a result, the process of fish fillet is much cleaner than fish meal (almost zero waste) and was solved the pollution problem to the neighbours and the environment with the fish meal plant (Noor *et al*., 2009). Based on the case study conducted by Department of Environment Malaysia, they has found that in In'Joy Marketing (M) Sdn. Bhd., a food industry has achieved saving in 23% of fuel oil used and consequently reduce the energy consumption. In addition, the productivity has improved by 60% which come from increase of production from 5 to 8 batches per 8 hour shift (Department of Environment, 2015).

However, beside CP benefits and the successful case study, there are still constraints occurs for the CP implementation. Study has found that space limitation, costly affair, lack of awareness and knowledge of available technologies as well as inadequate waste management skills (Daud, 2000) provide the limitation for the industry. In fact, with no legal requirement in Environmental Quality Act 1974 for CP implementation in Malaysia has also become inadequacy to the growth of CP implementation.

One of the main environmental concern from chicken slaughtering industry is the amount of untreated wastewater that contains high level of biochemical oxygen demand (BOD) dan chemical oxygen demand (COD) 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 increase of 0.5% from 2013. Even though the main culprit is still sewage, but the food processing industry contributes 27% of total amount BOD loading per day behind the sewage and agriculture sector (The Department of Environment, 2015). This is due to absence of onsite industrial effluent treatment, poor maintenance of treatment system and insufficient treatment capacity.

METHODOLOGY

The data was collected for five weeks at chicken slaughtering factory in Merlimau through the direct observation, reviewing relevant documents, and conducting detailed auditing as well as on site measurement. First, a preliminary site visit was conducted at the plant to obtain the information of company background and process flowchart. In is 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 activity 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 factors shows in Table-1 (Abd Rahman *et al*., 2014), and equation (1) as well as equation (2), provided from Inter-governmental Panel on Climate Change (Inter-governmental Panel on Climate Change, 2016).

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

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

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 reducing the carbon dioxide emission and overall production cost. Based on the option generated, it is important to perform the environment and economic feasibility study to prioritize the most feasible and beneficial options (Rahim and Abdul Rahman, 2015).

RESULTS AND DISCUSSIONS

Observation of overall process

Voltage (V) is the potential energy of electricity. Voltage can be present even if there is no current flow. For example, a car battery can have 12 volts in it even if it's not being used. That 12 volts is still there, waiting to be used, and is the battery's potential.

Figure-1, Figure-2 and Figure-3 show the overall process in the slaughtering factory from the initial step where the chickens are arrived at the factory until the packaging and further process (chicken nugget and chicken sausage product). The receiving process starts at 6.00 where the plant receives live chicken from the supplier. Then, the chicken will be calm down in the lorry after the trip for 30 minute with addition of fan. This process allows the chickens to be ready for slaughtering session.

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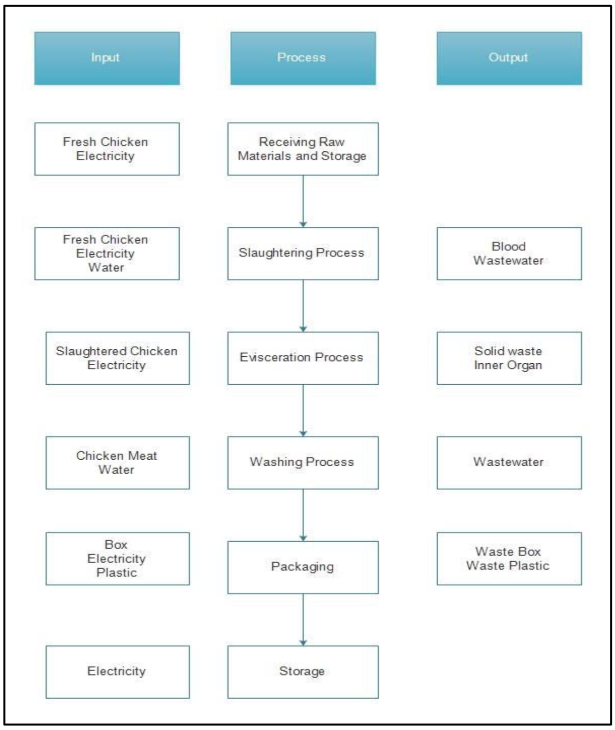

Figure-1. Chicken slaughtering process.

Live chicken were stacking through conveyor (hanging position). Throughout the uploading or stacking process, the workers should make sure that the chickens are still alive when they hanging the chickens. Then, proceed with stunning process that involving the two step which are the chickens should be soak in the water just to make the chickens are in wet and the chickens now will go through the stunning machine. This stunning machine is allow the chickens to be in static position so the slaughtering process can be done smoothly.

After that, the chickens were proceeding with slaughtering process and the worker inside the slaughtering room must have certificate halal slaughtering by Halal Malaysia. This is the important part where the chickens should be done in halal manner and eventually were checked by the Halal Malaysia officer. Then, the chickens are going to bleeding room where the chickens will be at this room for 4 to 5 minute so the chickens will completely finish bleeding.

Next, the chickens going to soak at scalding tank with temperature of the water is around 58 °C to 60 °C. This process is allow the chicken's feather to be easily remove for the next process. After that, the chickens going through the de-feathering machine so the chicken's feather were removed. After the chicken's feather were removed, the chickens are proceed with evisceration process at evisceration area. This area is the process that allow the chickens to be clean from blood, intestine and part of the chickens that maybe infected. This process also allow the side product process such as head, feet, gizzard and chicken's liver as requires from customer.

Next, final bird washing process for the chickens to be fully clean before going for chilling area. Then, the chickens are chilled in the chilling area. This chilling area is giving the instant cooling for the chicken to maintain the quality of the chicken throughout the earlier processes. Next, the chickens will be transfer to debone and packaging area. In this area, the chickens will be divided into three parts which are fully packaging, special part packaging and further stock. For each part, there having specification that follows the requirement from the customer. Next, the chickens from all three part will be transfer to different cold room, different storage and also direct to distribution area for deliver to customer.

The further process is the process of making chicken nugget and chicken sausage. Initial processes for this further process are including the chicken meat (boneless) process, preparation and ingredients process, mixing process and stuffing process. After this initial process done, the process of chicken nugget and chicken sausage will be separately conducted. For the chicken nugget process, the process will proceed to the frying process using frying machine. Then, the chicken nugget will transfer to freezing process using specific conveyor through the freezing machine. After the chicken nugget is in freezing temperature about below 0 °C, the chicken nugget is ready for packaging process using packaging machine. Then, this chicken nugget will transfer to storage and also ready for distribution to customer.

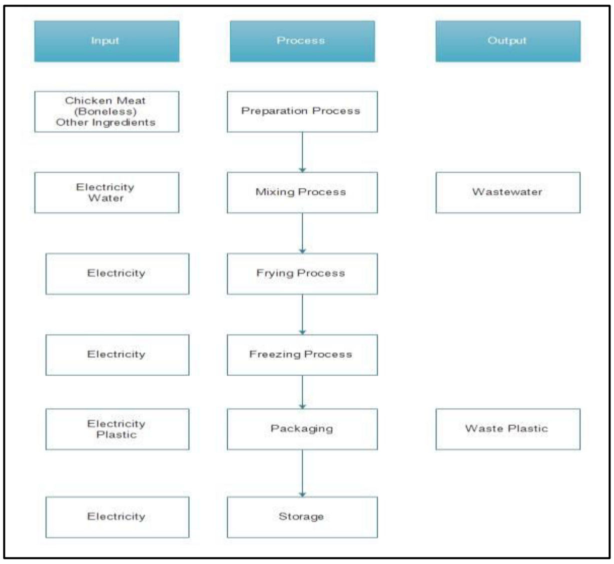

Figure-2. Chicken nugget processing flowchart.

The chicken sausage process is proceed after the initial process done. Then, the chicken sausage is ready to proceed with smocking and cooking process with temperature about 75 °C to 80 °C. After the chicken sausage is cooked well, the chicken sausage will be cold down to the room temperature and with help of showering process for speed up the cold down process. Then, the chicken sausage is ready for the next process which are the peeling process. This peeling process is the process that peel off the stuffing plastics that forming the chicken sausage shape (for original size of chicken sausage or mini chicken sausage product).

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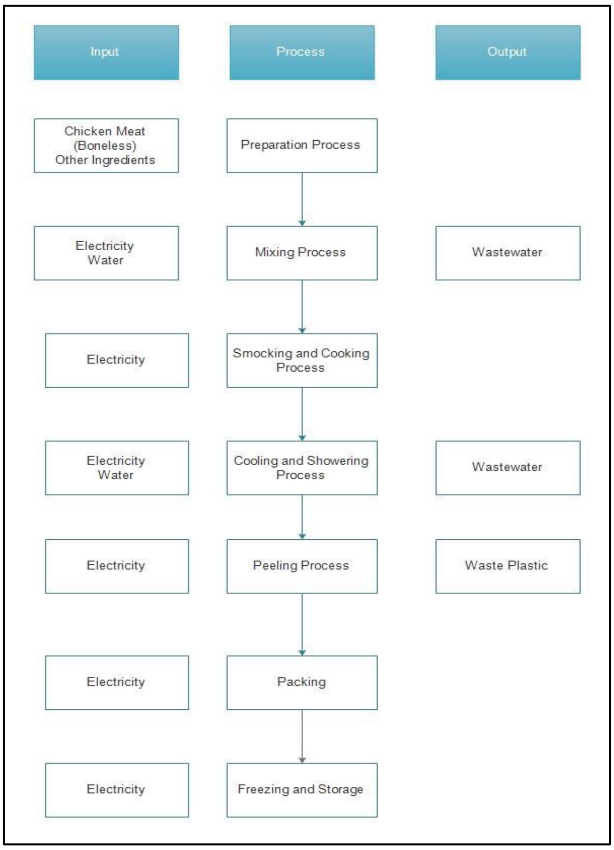

Figure-3. Chicken sausage processing flowchart.

After the peeling process, the chicken sausage will proceed with packing process and ready to be transfer by conveyor to the freezing process in the freezing machine. After the chicken sausage is cold enough at temperature below 0 °C, the chicken sausage will now be ready for packaging before transfer to storage. Then, the chicken sausage is ready to be distribute to the customer after transfer to the storage.

Resource utilized and waste produced amount

From the detailed audit conducted at the plant, summarize of resource consumption and waste produced shown in Table-2. The main use of waster is for slaughtering and washing process while only 5% were used in cleaning process and about 2% were used for domestic purpose. The water were purchased from Syarikat Air Melaka Berhad at RM2.15 per 1m3, resulting total water consumption cost of RM 90,300.00 per month.

Fuel (diesel) were used in the boiler to supply steam for the slaughtering process and sausage processing. The amount of fuel used is about 18,000 litre per month. Electricity is the highest amount of resources used in this plant amounting to 2,157,000 kWh per month. The main purpose for the electricity is for the operating the compressor which is to cold the storage room below -4° C. Subsequently, the process produced about 12,480,000 litre per month and 212,000 kg per month of wastewater and solid waste respectively. The wastewater is treated in the industrial effluent treatment system before discharge to the nearby river and solid waste is mainly generated from de-feathering process, evisceration process and packaging process.

Table-2. 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

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.

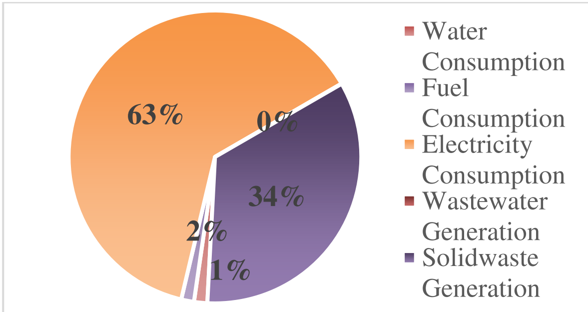

Figure-4. Percentage of carbon dioxide emission from chicken slaughtering plant.

The total amount of carbon dioxide emission from chicken processing plant is 2,296,151.60 kg 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 (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 high electricity consumption.

CP options and feasibility analysis for reduction of electricity consumption

The implementation of CP options at ammonia compressor room could contribute significant reduction of 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 is about 1,558,552.32 kWh per month which equal to 72% of the total electricity consumption.

Therefore, this study proposes three CP options to reduce the electricity consumption. First, company has to reduce the time to entry the product to the cold room.

Second, company has to reduce the number of door opening for the cold room, which can reduce the electricity consumption by reducing the heat loses to the environment. Moreover, it can increase the productivity by reducing the contamination due to opening and closing 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 the inverter for the compressor. However, the installation inverter incur additional cost for the company to implement this option.
The economic feasibility study shows that the company can save RM 27, 275.00 per month with reduction of 77, 928 kWh electricity per month with immediate return of investment for first and second option. However, with the installation of inverter to the compressor, the company can save RM 54, 550.00 per month with electricity reduction of 155,855 kWh per month and the return of investment of 1.5 months.

CONCLUSIONS

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

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