Cleaner Production Potentials in Seafood Processing Industry: A Case Study from Ho Chi Minh City, Vietnam

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Abstract:

This paper presents a case study on Cleaner Production (CP) potentials in seafood processing industry in Vietnam. Initial survey was carried out and various CP options were thus identified. After a detailed audit, reductions in energy and water usage were revealed with attractive payback periods. Up to 70 % of water consumed for table and floor cleaning could be saved by using pressurized hoses. Estimations and results in the factory show that up to 10 % of electricity bill could be reduced by suitably sizing and installing the capacitor banks. Major emphases are given to economically feasible solutions to reduce water and energy consumptions. Simple CP options were also identified for waste minimization and better house keeping.

1. Introduction:

The Vietnamese coastline is over 3,200 km long, offering great potential for marine fisheries to play an important role in Vietnam's emergent market economy. In 2000, the fishery sector created permanent jobs in the field of fishing, aquaculture and seafood processing for more than 3.4 million people, out of which 102,000 people work in seafood processing (Vietnam Fisheries Report, 2002). The raw materials for processed fish products come mainly from the southern part of the country, which account for 70% of total export value; the north and central regions of the country contribute only 10% and 20% respectively. Around 60% of factories are located in the south, mainly in coastal areas. The seafood export from Ho Chi Minh City (HCMC) alone is worth 239 million USD, ranking second behind Ca Mau province whose export value was over 300 million USD (Lindahl, 2002).

Agrex Saigon Company is a state-owned factory in Ho Chi Minh City, producing frozen and other processed food for export, mainly to Japan and for local markets. This factory was built in 1986 and put into operation in 1988. Currently it employs 600 people, with a weekly working period of 48 hours. The main objectives behind this study are to identify CP potentials in seafood processing industry and implementing them in reducing water and energy consumptions.

2. Production processes:

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The production process (flow diagram) of Agrex Saigon Company is shown in figure 1. This diagram also highlights the water flow, energy usage and material flow in the production processes.

In the receiving section, a batch of raw vegetables (yam, carrot, onion etc) is dipped into a 50 liter-basin where soil and unwanted materials attached on the skin are removed manually. Similarly, in the seafood receiving workshop, shrimps are graded and washed by dipping into batch basins. During grading, shrimps are chilled with ice. The ratio of ice and shrimp is about 1:1. This process alone consumes 4 % of total water demand. High quantities of saleable solid waste are also generated in this process.

In the processing section, shell picking and washing are done manually. This washed water, is replaced by another batch of fresh water. Similarly, the vegetables are skinned and then washed by sequential dipping into three basins in series. Chlorine solution of 100 ppm is used for the first two batches. The processing unit also generate large amount of saleable solid waste. The processed raw materials are now either grinded or cut into small pieces according to the product demand. Later, both the vegetable and the seafood are mixed in a centrifuge.

These mixed raw materials are transported or framed to the cooking unit. Trays containing offal are manually cleaned. The cooked products are then transported to the freezing section from where they are finally packed in a suitable container and stored. The cold storage accounts for the largest consumption of electricity demand. Almost 50% of the total electricity consumption is in the cold storage.

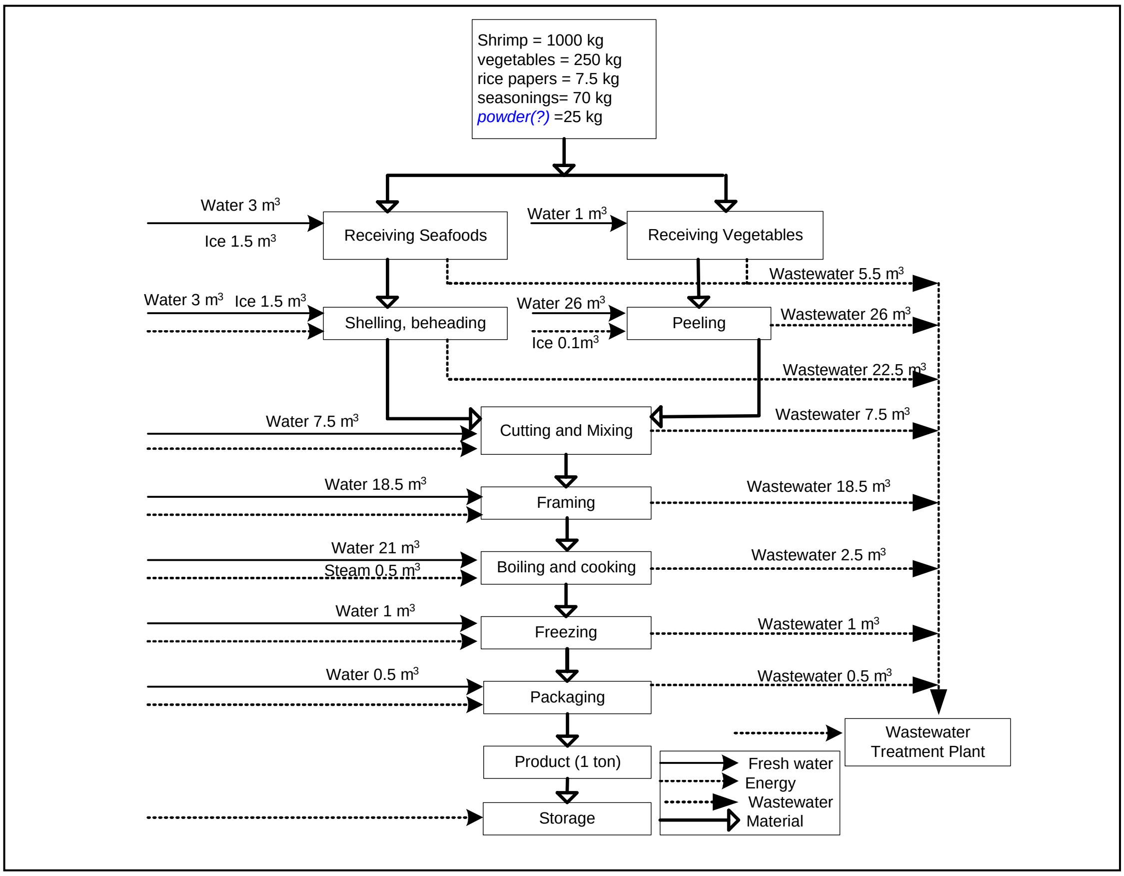

Figure 1:Production processes in Agrex Saigon Company

3. Methodology:

A detailed waste and energy audit was conducted and based on it, potential cleaner production were identified. Some of these options were, later implemented, and the following sections summarize these findings.

4. Observations:

4.1 Initial Survey

In Agrex Saigon Company, the major areas of concern are processing units, framing section, the cold storage and the diluted wastewater.

Processing unit: In this section the raw materials (vegetables and seafood) are continuously washed in fresh water and cut in to small desired pieces. These two units (seafood and vegetable processing) consume almost 50% of the total water supply and also large quantities of sellable solid waste are also generated from this unit.

Framing section: In this section, trays containing offal are manually cleaned using 3 steps: cleaning with water to scour the offal sticking to the trays; cleaning with detergent; and cleaning with water to remove the detergent. All these cleaning steps are conducted in 50 liter batch-basin in series. This operation consumes more than 30% of the total water consumption.

Cold Storage: Here the finished products are finally packed in a suitable container and stored. This storing accounts for the largest consumption of electricity demand of about 50% from the total electricity demand.

Wastewater: Currently, the wastewater generated from each operation is collected using a common drainage facility and sent to the wastewater treatment plant without any segregation.

- *Energy consumption:*

The specific energy consumption is about 1300 kWh/ ton of final product. The power factor of Agrex Saigon Company is low from 0.71-0.82 and the factory had to pay fee for the reactive energy. The high reactive power consumptions are due to the various electrical devices, such as electric motors and magnetic ballast for lamps. The reactive power depends on the power factor and the power consumed during the various periods (peak, partial peak and off-peak).

The main form of energy used in Agrex Saigon Company is electrical energy (66%). Besides electricity, diesel oil (23%) and LPG (11%) are also used in meeting the thermal demand. The factory consumes annually about 2 million kWh of electricity, which is obtained from two sources:

(1) National network, with three-part tariff (For industrial sectors):

- Partial-peak (Normal): 847 VND/kWh (from 4 AM to 6 PM)

- Peak period: 1474 VND/kWh (from 6 PM to 10 PM)
- Off-peak: 429 VND/kWh (from 10 PM to 4 AM)

(2) Hiep Phuoc IPP power grid: This power supplier charges a flat rate of 1,200 VND/kWh (including VAT). This power grid is used only during peak period to replace higher price electricity from the national grid.

Electricity consumption by freezers ranges from 150 to 220 kWh/ton of frozen shrimp or squid, and depends on the size of frozen products. The mean electricity consumption for frozen shrimps is 100kWh/ ton of products whereas, the average electricity consumption for filleting of herring ranges from 120 to 120 kWh/ ton of packed fillet products (UNEP, 1999). The main operation, which accounts for the maximum share of electricity consumption, is the final cold storage unit (Figure 2).

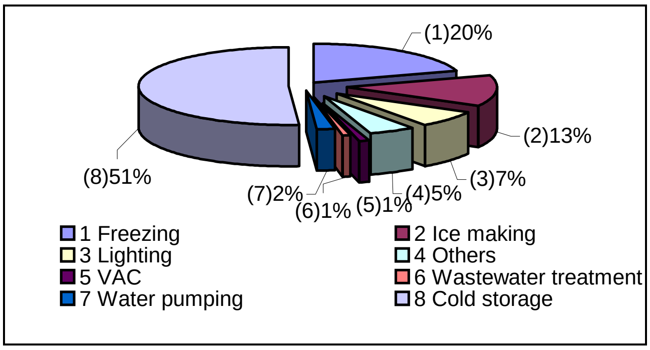

Figure 2. Energy distribution in Agrex Saigon Company

-Water consumption:

In this factory, the main environmental issue concerns the use of large amounts of fresh water for processing such as washing raw material and products, cleaning of machines, containers and flushing the working floor. Excessive use of water increases the amount of matter being washed out. Thus knowledge of the equipment and the evaluation of water use can lead to great reductions.

The water used in the surveyed factory was taken from the city water supply network at 4,170 VND/m^3. All the water used within the factory perimeter is fresh water. The clean water for the factory is taken from the municipal water supply, beside the water cost, the factory must pay water-discharging fee of 264 VND/ m^3, based on its water consumption. Water used for worker sanitation (toilet flushing, hand washing and bathing) was estimated to be 20 m^3/ day. The processing units (vegetable and seafood) consume the largest amount of water followed by tray washing. More than 80% of the total water demand was consumed by the processing units and tray washing operation (Figure 3). The water used in these units, are directly discharged to the common drainage.

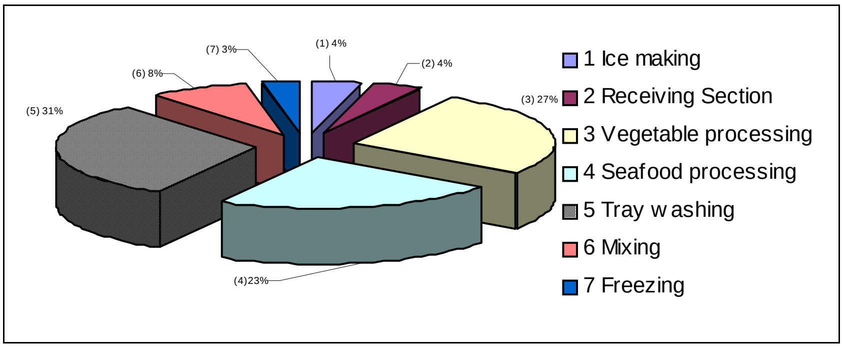

Figure 3: Share of water consumption by operations

-Material balance:

Input materials are shrimps, vegetables, rice paper, powder (?) and seasonings, etc. Based on the mass balance analysis, wastewater and solid waste generated from the factory are about 84 m^3 and 346 kg for each ton of product (Figure 4). Currently with a production capacity of 3.5- 4 ton/ day, the wastewater flow rate is about 300 m^3/ day and pollutant loads are 210 kg of COD/ day and 57 kg SS/ day.

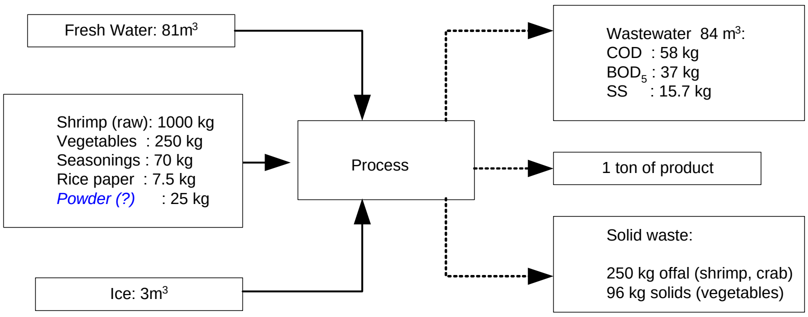

Figure 4: Material balance of foodstuff processing of Agrex Saigon Company

-*Wastewater*:

The quantity and quality of wastewater are highly dependent on the final products, types of raw materials processed and production processes involved. The main environmental concern of this industry is the use of large amounts of fresh water for washing raw material and products, cleaning of machines, containers and flushing the working floor. Table 1 shows the characteristics of wastewater discharged from this factory. These results, reveals the possibility of waste segregation. The quantity of wastewater is estimated to be 80 to 90 m^3/ ton of product. In general, a typical frozen seafood processing industry generates wastewater from 70 to 120 m^3/ ton of product (DOSTE-HCMC and CEFINEA, 1998).

Table 1 Characteristics of wastewater from different workshops

Parameter	Vegetable processing	Seafood processing	Tray washing	Combined wastewater
pH	7.6	7.1	7.4	6.8
COD (mg/L)	224	1930	516	700
BOD_5 (mg/L)	170	1160	120	440
SS (mg/L)	160	390	70	187
Total N (mg/L)	NA	255	NA	76
Total P (mg/L)	1.1	31	NA	20
Volume (m^3/d)	99	85	70	254 + 73*

* *Others*

-Solid Waste:

Solid waste is mainly in the form of organic wastes generated in the production processes. It consists of shrimp shells and heads from the seafood processing; skins (yams), roots (onions) and leaves (coconut) from vegetable processing and plastic bags containing seasoning, powder (?) and rice paper from mixing and framing operations. Even though, the solid wastes generated during the production processes are collected separately but still spillage occurs due to lack of suitable equipment for solid waste collection. The solid wastes were partially drained from the processing table along with the wastewater. Only shrimp shells and heads were sold for animal foodstuff processing whereas, other solid wastes are disposed off in the municipal landfill which could also be used for animal feeding.

5. Cleaner Production options: implementations and results

Based on observations during the audit, following cleaner production options were considered for implementation.

1. *Modification of framing operation*

In the framing section, the displacement of the previous trays by a new bigger stuffing container with a counter current washing operation showed a noticeable improvement in water saving. At the present working condition, the water consumption was reduced by 25% with a total saving of 21 million VND per year. Investment cost for implementing this option is 3 million VND with an attractive pay back period of 1.5 months.

2. *Use high pressure washer for cleaning activities*

With the introduction of pressurized washing, the water consumption for cleaning has greatly reduced. Normal cleaning (using un-pressurized hose and basin flushing) of each table and 4-5 m^2 of floor in this factory consumed about 2-3 m^3/ h of fresh water. Use of high-pressure washer showed that the water consumption for cleaning was only 0.25 m^3/ h. The water use for cleaning was thus reduced by about 70% and saving 29 million VND per year. The payback period for this option is 6 months. Other benefit by implementing this option includes:

- Reduced detergents use for washing;
- Better cleaning performance;
- Reduced washing time;
- Reduced investment, and operation and maintenance costs for the waste water treatment plant (WWTP); and
- Less labor.

3. *Recovery of cold water from flake ice machine:*

Squid preparation needs cold water for the initial soaking of the raw material, which is met by mixing fresh water at 30^0C with the ice. By setting up an insulated cold water pipe from the ice machine to the squid preparation area, the surplus cold water at 7^0C, coming from the ice removal process could be used for the soaking process.

This would further reduce the demand for producing ice and would save about 23,100 kWh of power each year (Table 2).

Table 2 Benefits of recovering cold water

Option	Saving			Pay back	Remark
	kWh/ yr	mil.VND/ yr	%		
Recover cold water from flake ice machines	23,100	10		1 year	Save energy

4. *Power Factor Improvement (installation of capacitor bank)*

Before the new regulation on reactive charge, the factory had to pay a power factor penalty because it was lower than 0.7. This amounted to about 70 million VND for a capacitor bank set of 300 kVA in 1997. In 1999, the factory products were integrated into international market, which led to the production growth; as a result, the factory had more equipment and consumed more reactive energy which led to further power factor degradation. Now, after the installation of capacitor bank the resulting power factor is approximately 0.99 and the factory do not pay any fee due to lower power factor. The power consumption was also reduced (Figure 5) and the factory's power bill also does not suffer due to the new regulation. This option for correcting the power factor saves about 12.6 million VND per month and has an attractive payback period of 5 months.

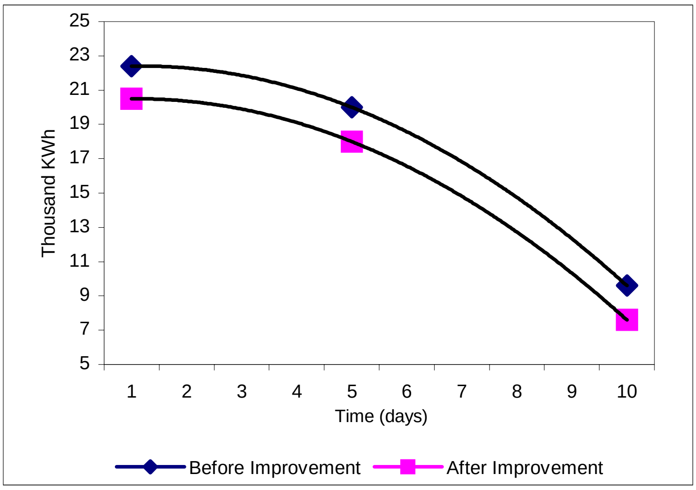

Figure 5. Power consumption before and after improving the power factor

5. *Replacement of magnetic ballast by electronic ballast*

As a means to energy saving the magnetic ballasts were replaced by electronic ballasts. The power demand of a full set (tube with ballast) is only 34 Watt, whereas that with magnetic ballast is 50 Watt. Fluorescent tube T10 (ϕ32) could be replaced by T8 (ϕ26-28) at the end of their economic life. This option has led to a considerable saving of 23,000 kWh per year and a total saving of 12 million VND annually. The payback period of the electronic ballast is 3.5 months.

The savings attained by implementing the above CP options are given in tables 3 and 4. The results show that by modifying some common operations and by introducing few energy-conserving options, the total amount of water and energy consumption has reduced significantly.

Table 3 Cost–benefit of the implemented CP options

Options	Inv.Cost (mil.VND)	Savings				Payback (months)
		kWh/ yr	m^3/ yr	mil.VND/ yr	%	
Modification of framing operation	3	-	6,750	21.6	25	1.5
Use of high-pressure washer	15	-	5,600	29	70	6
Replacement of magnetic ballast	7.5	23,000	-	18.5	-	3.5

Table 4 Benefit gained by improving the power factor

Items	Before	After
Energy bill (Bill for ten days)		
Power factor	0.82; 0.71; 0.73	1; 1; 0.98
Reactive charge (million VND)	0.65; 3.10; 1.13	None
Investment (million VND)		63
Saving (million VND/month)		12.6
Payback period (months)		5

6. *House keeping options:*

The temperature setting in the processing area should be maintained around (24 to 26)^{0}C and water meters should be installed in the processing and the framing section. This would reduce the humidity and would assist in monitoring the water usage. Other than that, use of suitable cleaning equipments and increasing the drain-hole diameter on the processing table would further reduce the water and offal spillage.

Other proposed CP options and their benefits were given under table 5.

Table 5 Proposed options for implementation

Option	Saving			Pay back	Remark
	kWh/ yr	mil.VND/ yr	%		
Change air blow motor of wastewater treatment plant	9,360	7.5		5 to 6 months	Save energy
Replace LPG by steam		26.6	20	-	Cost reduction
Proper temperature setting in working place	2,578	2	6	-	Lower humidity, better working conditions

6. Conclusion:

This case study exposed that, one can reduce energy and water consumption by implementing simple CP options without grand monetary investments. It also highlights the CP potentials in Vietnam seafood processing industries in terms of waste reduction, augmenting production and good house keeping practices. For Agrex Saigon Company, the potentials for CP options revealed an attractive payback. The total water consumption was reduced by more than 10 % by means of modifying the framing operation and using high pressure washers. With regard to power saving, more than 23,000 kWh would be saved per year by installing electronic ballast in place of the magnetic ballast.

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