MINISTRY OF INDUSTRY AND TRADE

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Guidelines for Resource efficiency and cleaner production in Vietnam's Pangasius processing sector

Acknowledgement

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The European Union has launched the SWITCH-Asia programme with a mission to assist Asian countries in their transition to low-carbon, resource-efficient and circular economies, and to promote sustainable production and consumption patterns in Asia and a greener supply chain between Asia and Europe. The programme aims to create a forum to promote policies and practices on sustainable production and consumption in Asia and to raise awareness and strengthen dialogue among domestic stakeholders. The SWITCH-Asia SCP Facility programme aims to strengthen the implementation of policies on sustainable production and consumption in the whole country.

Purpose of this manual

The objective of this document is to provide basic knowledge of the technological processes in the pangasius processing industry in Vietnam, and to provide a comprehensive approach to Resource Efficiency and Clean Production (RECP) so as to assist companies in implementing RECP assessment at their own facilities at present. The target group for using this manual includes factory leaders, technicians, and staff directly operating machinery and equipment in the processing plants. It will also be of reference value for managers, relevant ministries and departments, as well as organisations supporting the assessment, implementation and application of RECP in enterprises.

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ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
BOD5	Biological oxygen demand (over 5 days) - a standardised unit for measuring organic water pollution
CO_2	carbon dioxide
COD	Chemical Oxygen Demand - measures the quantity of oxygen required to degrade through oxidation all the organic and inorganic matter in wastewater
COP	coefficient of performance
EMS	Environmental Management System
EU	European Union
EUR	European Union euro - €
GHG	Greenhouse gas
GHS (UNECE)	Globally Harmonized System of Classification and Labelling of Chemicals (United Nations Economic Commission for Europe)
IGES	Institute for Global Environmental Strategies
IQF	individually quick-frozen
ISO	International Organization for Standardization
kWh/ton	kilowatt hour per ton
LED	light-emitting diode (light source)
LPG	liquified petroleum gas
MARD	Ministry of Agriculture and Rural Development
n.d.	no date
NH_3	hydrogen nitride (ammonia)
oz	ounce
PPE	Personal protective equipment
R12, R22	chlorodifluoromethane (freon), a refrigerant
RECP	Resource Efficiency and Cleaner Production
SCP	Sustainable Consumption and Production
SUPA	Sustainable Pangasius project
SUSV	Sustainable and Equitable Shrimp Production and Value Chain Development in Vietnam
tCO_2e	Tons of carbon dioxide equivalent
TPM	total productive maintenance
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
US	United States of America
USD	US dollar - $

VASEP	Vietnam Association of Seafood Exporters and Producers
VNCPC	Vietnam Cleaner Production Centre Co.Ltd.
WWF	World Wide Fund for Nature

TABLES AND FIGURES

PREFACE

Resource Efficiency and Cleaner Production (RECP) is an approach to reduce resource pollution through more efficient use of resources. RECP not only helps businesses to minimise production costs, it also contributes to improving environmental status, ultimately decreasing the cost of treatment for the environment.

These *Guidelines for Resource Efficiency and Cleaner Production in Vietnam's pangasius processing sector* were developed as part of a cooperation project between the Institute for Global Environmental Strategies (IGES) and the Vietnam Cleaner Production Center (BK Holdings – Hanoi University of Science and Technology).

The Guidelines were developed by Vietnamese experts with the aim of providing basic knowledge on the technological processes used in the Vietnam pangasius processing sector, and implementation procedures to apply RECP in businesses. They also bring relevant information to the pangasius processing sector, including development opportunities, production issues, and environmental protection, as well as best practices that can be applied in the Vietnamese context.

These Guidelines consist of 6 chapters:

Chapter 1: Introduction

Chapter 2: Natural resource use and environmental pollution

Chapter 3: Opportunities for resource efficiency and cleaner production (RECP)

Chapter 4: RECP – What is it, and how does it work?

Chapter 5: Review of RECP by topic

Chapter 6: Wastewater treatment

This is the first edition of the *Guidelines for Resource efficiency and cleaner production in Vietnam's pangasius processing sector*, so it is inevitable that some errors still remain. Thus the authors would be grateful to receive feedback for further improvement of this guide.

All comments and feedback are welcome and should be sent to Vietnam Cleaner Production Centre at this email address: vncpc@vncpc.org.

1. Pangasius overview

This chapter provides an overview of the pangasius processing sector in Vietnam and comprehensive information about the market trends and future of the industry. In this chapter, readers learn about the production procedure and resources used in pangasius production as well as the environmental issues related to production technology.

1.1 Pangasiidae species

The Pangasiidae family has around 28 freshwater fish species, which are classified as Siluriformes. They are found in fresh and brackish waters across southern Asia from Pakistan to Borneo. Among the 28 species of the family, *Pangasianodon gigas* is plant-eating and endangered, and one of the largest known freshwater fish.

In Vietnam, pangasius with compressed bodies, smooth skin, and short whiskers (barbels) live mainly in the Mekong river basin and basins of large rivers in the South. The Pangasiidae family consists of the following species:

- *Helicophagus waandersii*
- *Pangasianodon gigas*
- *Pangasianodon hypophthalmus*
- *Pangasius bocourti*
- *Pangasius conchophilus*
- *Pangasius krempfi*
- *Pangasius kunyit*
- *Pangasius larnaudii*
- *Pangasius macronema*
- *Pangasius polyuranodon*
- *Pangasius sanitwongsei*
- *Pseudolais micronemus*
- *Pseudolais pleurotaenia*

Eight of the 13 above-mentionned species are in *Pangasius*, 2 species are classified as *Pangasianodon* and *Pseudolais* and some as *Helicophasus*. Except for 3 species, namely *Pangasius conchophilus*, *Pangasius kunyit* and *Pangasius krempfi*, there are 3 groups in the Pangasiidae family: pangasius, Pteropangasius and Pangasianodon.

Among these 13 species, two have been recorded in the Red Book of Vietnam. *Pangasius sanitwongsei* has been listed in the Red Book since 1996, and *Pangasius gigas* since 2002. In addition, some species are farmed, and some on a large scale.

In the Pangasiidae family, there are a number of species that are raised in ponds, especially pangasius (*Pangasianodon hypophthalmus*). Today, farmed fish has become a farming and processing industry in which the Pangasiidae family is crucial.

Pangasius farming and processing has long played an important role in Vietnam and generates jobs for thousands of workers and farmers. The Mekong Delta region in Vietnam has an output of 400,000 tons of pangasius and Basa fish.

Concerning the consumption of pangasius products in North America, pangasius has become a popular seafood choice for consumers as domestic farming has expanded in recent years and the fish has become more available in markets and restaurants. In other continents apart from Asia, pangasius products, especially basa fish, are new to consumers, they are hard to come to European markets because of their high fate rate.

1.2 Biological characteristics of pangasius

Physiological features: Pangasius is a scaleless catfish with a long body, dark grey back, light silver belly, wide mouth, and 2 pairs of long whiskers. Pangasius live mainly in freshwater, they can live in slightly brackish water (salt concentration from 10–14%) and tolerate water with pH ≥5. Pangasius may die at temperatures lower than 15 °C but can resist temperatures up to 39 °C. Pangasius has an accessory respiratory organ and can also breathe with their bladder (also called 'air bubble') and through their skin, so these fish can tolerate an environment without dissolved oxygen. Having a low oxygen threshold enables pangasius to live in dirty ponds.

Food sources for pangasius: Strict feeding requirements are mandatory for pangasius to be considered exportable, e.g to the EU and other markets. When the yolk sac of farmed pangasius fry has been absorbed, they eat the natural food in the hatching tank, cannibalizing each other. Even river-caught pangasius can be observed eating each other at the bottom of the fishing net. The fry eat zooplankton which are as same size as their mouths. When pangasius fry have grown larger they become omnivores but primarily carnivores, and it is easy for them to switch foods. In ponds, pangasius has the ability to adapt to many types of food, including humus, organic residues, or benthic animals.

Growth characteristics: Pangasius have a relatively fast growth rate and when the fish are young, they grow rapidly in length. After being farmed in the pond for 2 months, they reach a length of 10–12 cm (14–15g/fish). After reaching 2.5 kg fish weight increases faster than body length. In nature habitat, pangasius can live for more than 20 years. Pangasius in the wild have been seen weighing 18 kg and with a length of 1.8 m. A fish in an aquaculture pond can weigh 1–1.5 kg. In the following years, weight increases faster, sometimes at the rate of 5–6 kg/year, depending on pond environment and food supply as well as how much protein is in the food. Fulton fatness of pangasius increases gradually with weight is more rapid in the early years. Male pangasius usually have a higher fat rate than females, with fat usually decreasing during spawning season.

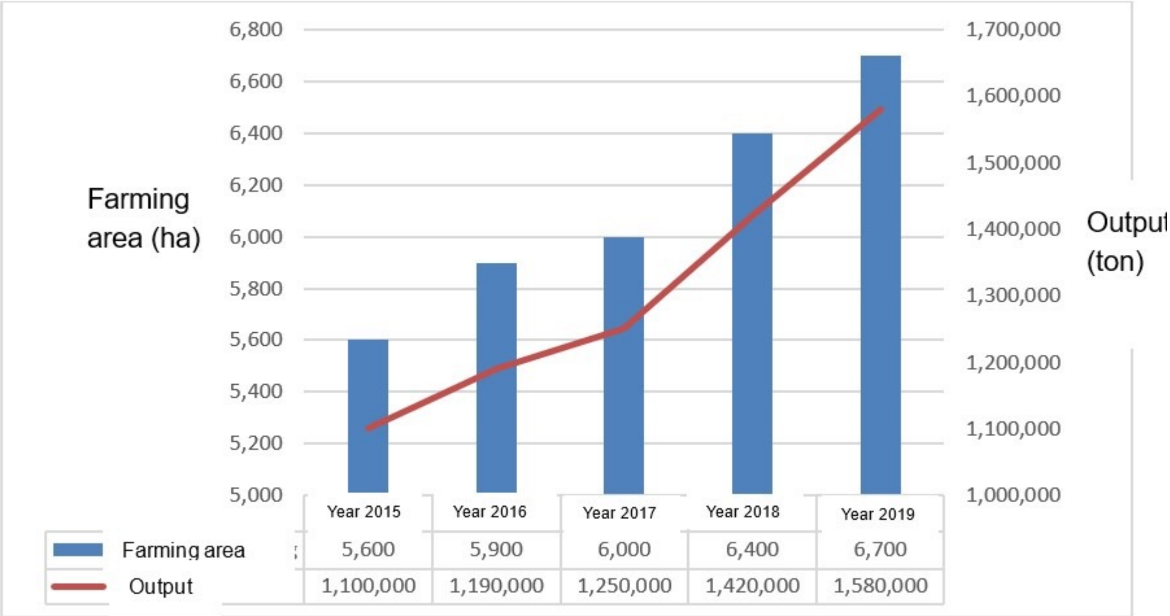
Reproductive features: Male pangasius reach maturity at age 2 and female fish at the age of 3 or more. The natural breeding season is at the beginning of May (lunar calendar). Under good farming conditions, pangasius can spawn in early April. The reproductive capacity is from 100,000 to 200,000 eggs/kg, and the age of maturity is from 3–4 years old.

1.3 Pangasius processing sector in Vietnam

1.3.1 Pangasius production and exportation in Vietnam

Pangasius is a strategic seafood product of Vietnam and the second most important white aquacultured fish product on the global market.

In 12 years (2000–2012), fishing farm areas have increased 5 times; output has increased nearly 29.8 times from 37,500 tons to 1,119,000 tons; export value increased 43.6 times from USD 40 million to USD 1744 million; the number of export markets have increased from a few Asian countries in 2002 to 142 countries and territories across all continents in 2012 (Fig. 1).



Source: Directory of Fisheries, MARD

Fig. 1. Area and output of pangasius in the Mekong Delta, 2015–2019

In terms of aquaculture, pangasius is farmed in 10 provinces of the Mekong Delta region including: An Giang, Dong Thap, Tien Giang, Can Tho, Vinh Long, Ben Tre, Hau Giang, Soc Trang, Tra Vinh, Kien Giang. In addition, pangasius has been raised on aquaculture farms in 2 other provinces: Tay Ninh and Quang Nam. Among the above provinces, the 5 key pangasius farming provinces (accounting for 82% of total national output) are Dong Thap (34%), An Giang (19%), Ben Tre (11%), Can Thơ (11%) and Vinh Long (7%).

There are five leading corporations in pangasius processing with a processing capacity of more than 100 tons of raw material/day accounting for 34% of all output, 10 companies with a processing capacity of around 100 tons/day accounting for 25% of all output, and many smaller companies with a processing capacity of under 30 tons/day.

However, the rapid development of the sector has also raised concerns about the environmental and social impact of pangasius farms and processing facilities and how to ensure the long-term sustainable development of the sector. With a large amount of waste and a relatively high concentration of pollutants, waste from pangasius farming ponds affects the environment not just in the immediate vicinity of the farms. The amount of wastewater discharged to produce a ton of finished pangasius product is 4,023 m3, of which the amount of water taken from the river accounts for 63%, from the main canal 19%, and from fields or gardens 11%. On average, 450–480 tons of feed are used to feed 300 tons of finished fish products; however, only about 75% of this feed is eaten by the fish while the rest is left rotting at the bottom of ponds and rivers.

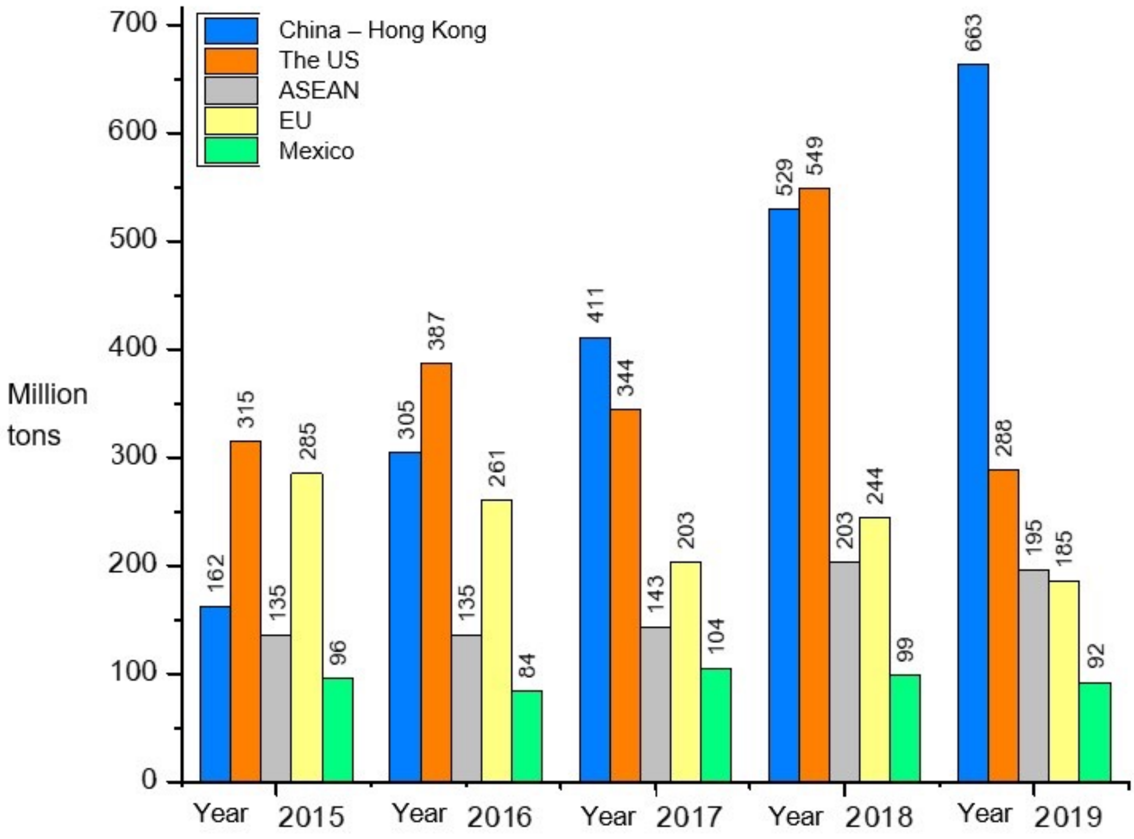
1.3.2 Main export markets

Pangasius is becoming more and more popular in the world thanks to its nutritional value.

In 2012, Vietnam exported pangasius to 142 markets, an increase from 136 markets in 2011. The top 10 pangasius markets include the EU, the US, Asean, China and Hong Kong, Mexico, Brazil, Egypt, Saudi Arabia, Colombia, and Australia, accounting for 77.5% of the total pangasius export value in 2012. Among the 10 main import markets for Vietnamese pangasius, there were 7 markets with a decrease in imports compared to 2011, of which the biggest decrease were the EU and Saudi Arabian markets. The three remaining markets, the US, China/Hong Kong and Egypt, increased 8.2%;

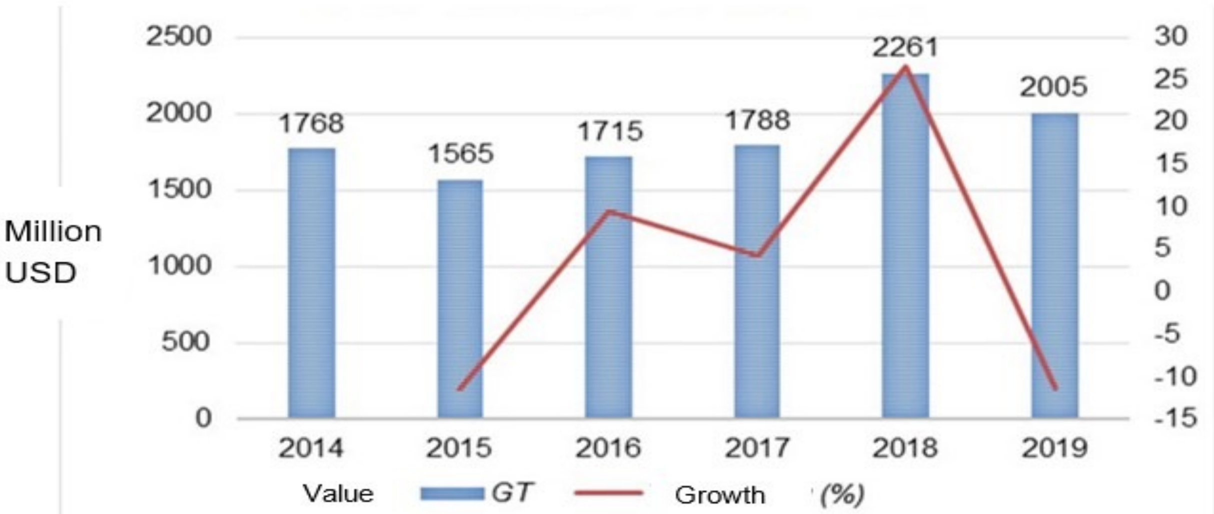
31.5% and 29.1%, respectively; however, these rates are much lower than those of the previous years, and some new markets have grown only gradually.

In 2019, Vietnam exported pangasius products to 131 markets. The top 8 markets include China/ Hong Kong, the US, the EU, ASEAN, Mexico, Brazil, Colombia and Japan; total exports reached the value of USD 1.61 billion, accounting for 80.4% of total export value (see Figs. 2 and 3).



Source: VASEP

Fig. 2. Top 5 export markets for Vietnam pangasius, 2015–2019



Source: VASEP

Fig. 3. Vietnam pangasius exports, 2015–2019 (Source: VASEP)

1.4 Frozen pangasius processing: Summary of the main production steps

The pangasius processing sector produces mainly frozen fish fillets. The production process includes the following technical steps , summarised in Table 1, below (see Chapter 3 for further details on each step):

1. Receiving live fish
2. Bleeding and washing (1)
3. Filleting
4. Washing (2)
5. Skinning
6. Trimming
7. Parasite inspection
8. Washing (3)
9. Disinfection
10. Sorting and weighing
11. Washing (4)
12. Tray or frame laying/IQF preparation
13. Cooling and pre-freezing
14. Freezing
15. Glazing and hardening (2nd freezing)
16. Weighing and packaging
17. Frozen storage

Table 1. Summary of the main steps in frozen pangasius fillet processing

Technical step	Technical requirements	Process description
1. Receiving live fish	Live fish of good quality arrive at the receiving area of the factory (disease-free, defect-free, and having met antibiotic residue standards)	Live fish are transported from the fishing/aquaculture area to the production factory by well-boats equipped to store and transport the live fish. On the wharf they are put into specialised plastic containers and then quickly transferred to the receiving area by conveyor belts or small trucks. At the receiving area for quality inspection, the declaration of origin and antibiotic test report is completed.
2. Bleeding and washing (1)	All water used throughout processing to wash fish carcasses and fillets must be potable (drinking water quality). Wash slaughtered fish for 10–20 min	After weighing, the fish are killed by cutting the gills/fauces (the arched opening at the back of the mouth leading to the pharynx), then put into a sink to bleed. The purpose of bleeding is to whiten the flesh; they are then thoroughly washed again to rinse off all remaining blood.
3. Filleting	The fillets must be smooth, flat, and without scratches or tears, or bones left in the meat	With a specialised knife to fillet the fish, the meat is separated from the fish body on both sides, and the head and internal organs (viscera) are removed under continuously running water. The fish must be handled carefully to avoid rupturing internal organs or leaving bones in the flesh.

Technical step	Technical requirements	Process description
4. Washing (2)	Wash batches of fillets in clean water: temperature, 4–10 °C; chlorine concentration, 10 ppm. Water for washing is to be used only once, for a maximum of 50 kg of fillets. Then discard and refill sink with clean water.	The fillets are washed through 2 sinkfuls of clean water. During washing the fillets must be stirred thoroughly by hand to remove blood and viscous matter, and any other impurities.
5. Skinning	After this step no skin remains; there are no cuts or tears in the fillet. Temperature of washing water ≤ 8 °C, chlorine concentration 10 ppm.	Use a knife or peeler to remove the skin. The correct technique is to gently manipulate the fillet while skinning so as not to cut or tear the fish meat
6. Trimming	No red muscle or fat layers left on the fillet, no bones in the flesh. Fillet temperature ≤15 °C	The trimming step removes the red muscle and fat just under the skin of the fillet. The fillet after trimming must be clean of red surface muscle and fat layers and without cuts or tears, it must be boneless, and the surface of the fillet must be smooth.
7. Parasite inspection	There must be no parasites left in or on the fillets. QC check every 30 minutes	Each fillet must be visually inspected for parasites. After this step, all fillets must be parasite-free; any fillets with parasites are to be discarded.
8. Washing (3)	Water temperature ≤ 8 °C. Change water after every 200 kg fillets	The fish are washed through 2 sinkfuls of clean water at ≤ 8 °C. Gently hand-stir the fillets. Wash no more than 200 kg of fish in any one batch of clean wash water.
9. Disinfection	Temperature of the chemicals + water solution, 3–7 °C Mixing time is at least 8 min and no more than 40 min. Chemical solution concentration and amount of salt depend on the destination market for the final products. Fish temperature after mixing < 15 °C	After the 3rd washing, weigh the fish and put them into the mixer: 100–400 kg/batch depending on the size of the mixer. Then add the disinfectant solution (scale ice (flake ice) + salt + chemicals + cold water at 3–7 °C) with a 3:1 ratio of fish:chemical solution.

Technical step	Technical requirements	Process description
10. Sorting and weighing	Fish fillets are sorted by size, by gram/piece, oz[1]/piece or according to customer requirements; a 2% margin of error is allowed. Weighing is based on customer requirements for each size and type of fillet	Fish are sorted into different sizes, e.g. 60–120; 120–170; 170–220; >220 (g/piece) or 3–5, 5–7, 7–9, 4–6, 6–8, 8–10, 10–12 (oz /piece); or according to customer's request. The sorting operation must be carried out rapidly to ensure that fish temperature does not exceed 15 °C. Fish are weighed according to each size and type based on customer requirements.
11. Washing (4)	Temperature of wash water ≤ 8 °C. Change water after every 100 kg fish	Fillets are washed in a clean water bath at ≤ 8 °C, and gently stirred by hand. Wash no more than 100 kg of fish per change of water.
12. Tray or frame laying/IQF preparation	The blocks of fillets will depend on either size, separate type or customer request	Frozen blocks: after being washed and drained, the fillets are then placed into blocks or frames on trays. Individually quick-frozen (IQF) products: products are stacked one at a time in a single layer on the conveyor belt. All fillets must be of the same size and weight.
13. Cooling and pre-freezing	Pre-freezing temperature: -1 to -4 °C Cooling time: ≤ 4 hours.	If fillets have not been frozen immediately after being formed into blocks, they must be pre-frozen at a specified temperature and time. Products must be pre-frozen before entering frozen storage, and the pre-freezing temperature within the cooling storage place should be maintained at -1 °C to -4 °C, with cooling time no longer than 4 hours.
14. Freezing	Freezing time ≤ 3 hours (block). Core temperature of products: ≤-18 °C. Temperature of block freezer: -35 to -40 °C IQF Freezer: -40 to -45 °C	For freezers, put them on until when there is a thin layer of ice on the new plates for fillets to be frozen; Freezing time should not be longer than 3 hours. Core temperature of products is ≤-18 °C. For IQF freezing: when the temperature inside the freezer reaches -45 °C, the product will be added; freezing time 10–15 min depends on product size (capacity of 500–750 kg/h). Workers must pay attention when placing the frozen products on the conveyor belt: the fish should lie flat and look attractive.

1 The abbreviation oz stands for ounce, a non-metric unit of weight representing approximately 28.35 g.

Technical step	Technical requirements	Process description
15. Glazing and hardening (or 2nd freezing)	Fillets must be handled carefully to avoid breakage Glazing rates are 10%, 15%, 20%, 25%, or 30%. 2nd freezing temperature: -30– -35 °C	Glazing is the application of a layer of ice to the surface of a frozen fish product. After products are glazed, they are unblocked with water applied to the bottom of the mould/plates to separate and pack the fillets. Fillets Manual surface glazing: dip each basket of weighed fillets in a barrel/bucket of very cold water with a temperature of -1 to -4 °C depending on the rate of surface freezing to adjust the time needed to glaze the fillets. IQF Automatic IQF surface glazing: fillets travel along the conveyor belt from the IQF step to the continuous freezing tank. After the surface has been glazed, the product runs through a second freezing step to ensure that the core temperature of the fillets ≤ -18 °C.
16. Weighing and packaging	Packaged for each individual customer Packaging time should not exceed 30 min	Products of the same size are put in plastic containers or cartons depending on customer requirements. Pack the correct size, type and specification of fillets based on individual customer requirements. Package information is written in accordance with current regulations in Vietnam or at the request of customers
17. Frozen storage	Cold storage temperature: -20 °C ± 2 °C	After packaging, the final products will be transferred to cold storage, sorted by size and maintained at a temperature of -20 °C ± 2 °C.

2. Natural resource use and environmental pollution

This chapter provides specific information on raw material and energy consumption and the impact of the pangasius frozen fillet production process on the environment and on occupational health, as well as the potential application of Resource Efficiency and Cleaner Production (RECP) in the frozen pangasius fillet processing industry.

The process of frozen pangasius fillet production uses large quantities of water and energy, while generating solid, liquid and gaseous waste as presented below.

2.1 Raw material and energy consumption

2.1.1 Raw material consumption

Frozen pangasius fillet processing factories

The main product of the pangasius industry is frozen fillet for exporting. The main exporting markets of frozen pangasius fillet include Europe, the US, ASEAN, China, Hong Kong, Mexico, Brazil, Egypt, Saudi Arabia, Colombia and Australia.

The input used for the frozen pangasius fillet processing industry is pangasius raised in the aquaculture areas of the company, or in other satellite aquaculture areas of farmers who have product outsourcing contracts with the fillet factory. The pangasius fish brought to the fillet processing factory weigh, on average, 1–1.5 kg.

Raw material consumption levels depend on the weight of the fish, the quality of the raw materials (whether it is mixed with other kinds of fish or not), the scale of the processing factory and the ice-glazing/surface freezing rate of the product, etc. Raw material consumption for each ton of product is presented in Table 2.

Table 2. Raw material consumption in frozen pangasius fillet processing factories

Material	Unit	Average consumption
Raw fish	ton/ton of frozen fillet	1.9–2.5

Source: SUPA - VNCPC Project

Pangasius by-product factories

Pangasius by-product factories buy inputs which are by-products or waste such as the head, bones and other solid waste of pangasius fish from frozen fillet processing factories in nearby industrial zones, then directly transport the material to the factory for rapid processing on the same day. From one kind of input the factory can produce two products, including fish powder and fish oil, and furthermore obtain the fish swim bladder as by-product.

Material consumption levels are given in Table 3.

Table 3. Material consumption in Pangasius by-product factories

Material	Unit	Average consumption
By-products of frozen pangasius fillet factories	Ton ton of fish bladder	34.0–34.6
	Ton/ton of fish powder	5.1–5.2
	Ton/ton of fish oil	4.9–5

Source: SUPA - VNCPC Project

2.1.2 Energy consumption

Frozen pangasius fillet processing factories

The frozen pangasius fillet processing industry uses large amounts of energy. Most of the frozen pangasius fillet processing factories are key energy-consuming facilities. The energy used by frozen pangasius fillet processing factories consists mainly of electricity and a small ratio of LPG used for the cooking needs of the workers, but no thermal (boiler) energy is consumed. The thermal (boiler) energy is used only in pangasius by-product (fish powder and oil) processing factories.

Electricity is used in frozen pangasius fillet processing factories to operate the freezing appliances and machines (freezing, scale ice production, cold storage), and for lighting, cold water, workshop air conditioners, hot water for industrial sanitary uses, wastewater treatment and other loads.

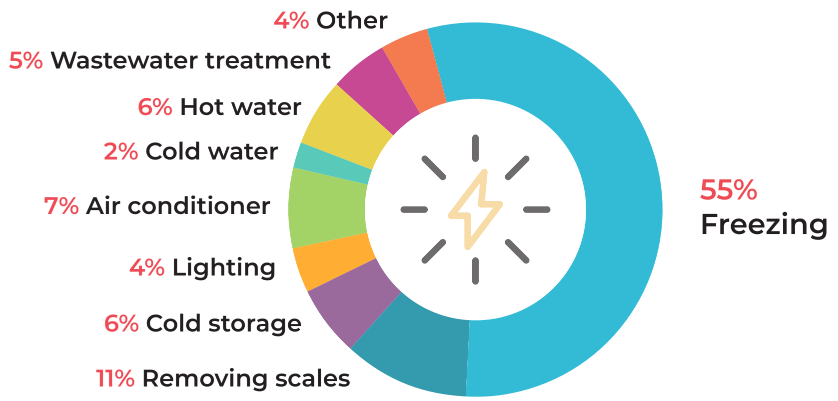
The energy consumption level varies across the factories depending on their processing procedure, product ice glazing/surface freezing rate, and the availability of cold facilities for the intermediate- or long-term storage of products. The energy consumption per ton of product is given in Table 4.

Table 4. Energy consumption level in frozen pangasius fillet factories

Energy	Unit	Average consumption
Electricity	kWh/per ton of frozen fillet	720–1300

Source: SUPA - VNCPC Project

The allocation of electricity consumption in frozen pangasius fillet processing factories is demonstrated in Figure 4.



Source: SUPA - VNCPC Project

Fig. 4. Average electricity consumption allocation in frozen pangasius fillet processing factories

Pangasius by-product factories

The electricity used in pangasius by-product processing factories include electricity and thermal (boiler) energy. Because these factories use one resource input to product different types of products and there is no electricity meter for each step of production, it is impossible to calculate energy consumption for each product. Energy consumption is therefore calculated based on resource input. Energy consumption per ton of input material is given Table 5.

Table 5. Electricity consumption level in pangasius by-product processing factories

Energy	Unit	Average consumption
Electricity	kWh/ton of raw material	34–42
Heat	MJ/ton of raw material	3,192–3,878

Source: SUPA - VNCPC Project

2.2 Water consumption

Frozen pangasius fillet processing factories

Frozen pangasius fillet processing factories use large quantities of water. A pangasius processing factory usually uses about 500–2000 m3 water/day. The factories usually use river or well water and treat the water to obtain potable water for use in processing. Only those factories situated in industrial zone will buy water supplied by the industrial-zone infrastructure companies.

Water usage in the factories includes:

- water consumption caused by evaporation of cooling tower (with low-wattage refrigeration system – cooling tower – condenser), condensing system (with high-wattage refrigeration system – condensing system)
- water consumption caused by the processing process in which water is used to clean raw material/ semi-finished product/final products, as well as to clean the factory and processing tools (e.g. knives, baskets, etc.)
- consumption for daily activities of factory workers (cooking, washrooms)
- consumption for watering plants within the factory

The level of water consumption of each factory depends on their manufacturing technology, the type of inputs (fresh fish or semi-finished products bought from other factories), the level of maintenance for the water system of the company, the skills of processing workers, workers' awareness concerning water saving, etc.

The water consumption per each ton of products is given in Table 6.

Table 6. Water consumption level in frozen pangasius fillet processing factories

Water consumption	Unit	Average consumption
Water	m^3/ton of frozen fillet products	15–50

Source: SUPA - VNCPC Project

Pangasius by-product factories

Pangasius by-product processing factories use less water. Water in these factories is used:

- to clean the factory, machineries and water supply for boilers
- for daily drinking and cooking water
- for watering the plants at the factory

Water consumption per each ton of resource input is given in Table 7.

Table 7. Water consumption in pangasius by-product processing factories

Water consumption	Unit	Average consumption
Water	m^3/ton of raw materials	0.13-0.14

Source: SUPA - VNCPC Project

2.3 Consumption of chemicals

Pangasius processing factories use very few chemicals. The chemicals used in the processing workshop are generally chlorine for sanitation, detergents (soap) to clean processing tools, and LPG used to prepare workers' meals. Depending on the geographical location of the factories and the surrounding environment, rodenticides and insecticides may be used.

In frozen pangasius fillet processing factories, there is always a refrigeration system which uses NH_3 or R22 as cooling agents (pangasius by-product processing factories do not have a refrigeration system).

Depending on their properties, chemicals can cause injuries or harm for people, such as skin rashes and allergies in addition to other dangerous physical phenomena such as explosions, poisonous gas emissions, and so on.

Incorrect storage and control and misuse can lead to environments degradation and human health problems.

2.4 Environmental issues and occupational safety and health

As with many other food processing activities, the main environmental impact related to pangasius processing activities is wastewater. In addition, noise, smell and solid waste might also be problematic in some companies.

Wastewater

Frozen pangasius fillet processing factories use large quantities of water and therefore discharge a large quantity of wastewater. The wastewater of frozen pangasius fillet processing factories comes from three main sources:

- wastewater from production support systems (cooling towers, condensers): the condenser or cooling tower uses circulating water to cool down gases and condense them into liquid form. During the cooling process, water will continuously evaporate, which causes solid matters dissolved in the water to condense. When these solids become saturated, they create deposits in heat conducting pipes leading to high energy losses. Therefore, the cooling water must be periodically discharged. Wastewater of this type is generally very hard (alkaline) because it contains high levels of calcium, magnesium, silica, along with dust sludge (from the air) and micro-organisms (slime).
- domestic use wastewater: workers' toilets produce organic pollutants such as faeces, urine, disease viruses and suspended solids. The main polluting elements include BOD_5, COD, nitrogen and phosphorus. Wastewater from the workers' kitchens contains pollutants such as fat, pieces of food, and other organic wastes.
- production wastewater: this includes water used to wash raw inputs and semi-finished products and to clean the workshops, equipment and tools, ice that has melted, etc. Production wastewater contains large quantities of fish blood, organic matters, suspended solids, fish pieces and fish oil: pH = 6.5–7.0; SS = 500–1200 mg/L; BOD5 = 500–1500 mg/L; COD = 800–2500 mg/L; total nitrogen = 100–300 mg/L; total phosphorus = 50–100 mg/L; total lipids = 250–830 mg/L. This protein- and nutrient-rich wastewater usually produces foul odours caused by the degradation of amino acids and proteins, making an ideal breeding ground for microbes, which cause disease from decaying aquatic products and in turn pollute the water bodies (ponds, lakes, rivers) that receive the wastewater. In addition, when waste matter builds up, it causes eutrophication (lack of oxygen) in the surrounding ponds and lakes.

Emissions

Emissions are produced by frozen pangasius fillet factories as the unpleasant-smelling gases from raw materials (dead fish), semi-finished products, sanitising chlorine and possibly NH3 leaked from refrigerating equipment in the workshop. Raw waste material odours come from solid waste storage. Leaked NH3 odours come from the refrigeration compressor area (there will be especially high leaked NH3 when the factory uses a pistol refrigeration compressor).

In pangasius by-product processing factories, very malodourous emanations are produced by raw pangasius waste material in the receiving area of the factory. Pangasius by-product processing factories always have boilers fuelled with coal, furnace oil (FO) or biomass produce boiler emissions in the production support area. Drying ovens in workshop areas also cause high levels of odour and dust which pollute the working environment.

A highly odorous work environment causes fatigue, reduced productivity and occupational diseases such as joint, arthropathy, calf and ankle swelling, etc. among the workforce, while polluting the surrounding air.

Solid waste

The solid waste of frozen pangasius fillet processing factories includes fish heads, bones, skin and viscera. These organic matters, saturated in protein, calcium and phosphorus, ferment and decay quickly in hot, humid weather. When they are not collected and transported properly to the pangasius by-product processing factory, the degradation of the organic matters in the solid waste will cause foul odours and air pollution.

2.5 Opportunities for RECP

2.5.1 Saving water

Today, fresh water is a limited, over-exploited natural resource. Saving water will help to protect the environment and reduce production costs.

As described in the preceding sections, water in the pangasius processing sector is used for four main purposes, namely refrigeration system cooling, in production processes, for daily consumption by the workers, and for watering the green plants at factories. Because the water is mainly sourced from river or wells, frozen pangasius fillet factories usually pay no attention to how much water they are wasting. Thus there is significant potential for water savings in these factories.

Practical experience has shown that it is possible to economise 10%–30% of the water currently being used in the pangasius sector, if water saving measures are applied within the factories.

Popular water saving measures

- Enhance water system maintenance
  - Detect and fix underground water pipe breakages immediately
  - Avoid overflow or leaks in the reservoir of the water condenser/ refrigeration cooling tower
  - Detect and fix leaks/breakages of taps in workers' toilets, etc.
- Reduce the ideal water flow used to wash raw inputs and semi-finished products
- Do not completely fill washing containers and avoid overflow
- Use a high-pressure water hose with a portable shut-off valve attached to the end of the hose to clean the workshop floor instead of common soft hoses which require squeezing the open end of the hose to create a pressure spray
- Turn off water taps when not in use or during lunch breaks
- Plant watering: use ø20 water hoses with a nozzle to produce arain spray with a flow of 560 l/hour and a shut-off valve attached to the end of the hose; ø27 or ø34 hoses can also be used with a flow of 3–5 m^3/hour
- Watering plants in the morning or evening to maximise water absorbed into the earth to reduce evaporation; this method can save up to 30% water
- Adjust the flow valve in toilets: 5–7 l/min for hand-washing taps, 9–12 l/min for showers.
- Reuse water whenever possible

2.5.2 Material consumption reduction

Improving the quality of inputs and enhancing material use efficiency are key to increasing the economic efficiency of manufacturing processes. The quality of input materials depends on the process of raw material treatment from collection/reception and the waiting time for processing. The speed at which fish flesh decays doubles for every 4 °C of temperature increase.

Reducing the quantity of raw materials used for production, or increasing product yield by a fixed amount of raw inputs can be achieved through technological adjustments or changes in production control and management. For the pangasius industry, raw material reduction means reducing the quantity of fish and supporting materials, such as carton packaging, plastic, twine, etc. on each unit of frozen product, and increasing the reuse of production waste to create useful by-products.

It is possible to reduce resource consumption through internal management and control. In general, good practices of internal management and control include educating and training staff; writing guidelines for equipment maintenance and resource storage; improving workers' knowledge of the input and output of the process and including everything as part of the process: raw materials, chemicals, heat, electricity and water, as well as the output of the product, wastewater, dust and gas emissions, waste sludge, solid waste and by-products.

Key environmental benefits that can be achieved through good internal management and control are saved production cost thanks to a reduction of raw inputs, chemicals, water and energy, along with lower quantities of solid waste and pollutants in wastewater and emissions. At the same time, the work environment is also improved.

Staff education and training is important for efficient use of resources and environmental management. All staff should clearly understand the necessary preventive measures to avoid wasting resources and causing pollution. Training should include knowledge about resources (raw materials, chemicals, energy, water), production processes, and specific equipment.

High-level managers should have clear commitments on environmental improvement, especially in the form of environmental policy with a clear implementation strategy and they must share the policy with all staff.

Technology upgrading needs to be implemented in parallel with good environmental and sanitary management. Good control of processes that potentially cause pollution requires good execution of multiple elements of an environmental management system (EMS). The implementation of an input and output supervisory system is the prerequisite for determining prioritised areas and options to improve environmental efficiency.

2.5.3 Waste flow reduction

Frozen pangasius fillet processing factories generate large amounts of wastewater and high pollution loads. Wastewater includes production wastewater (at a rate of about 15–50 m^3/ton of frozen product) because the manufacturing process uses large quantities of water for washing and cleaning the raw fish. In addition, the quantity of wastewater discharged from domestic use in the factory is also significant since factories hire many workers. Each factory usually has from 1000–4000 workers and each worker discharges about 100 l of wastewater per day.

High wastewater and pollution load general overload sewage treatment systems and cause environmental pollution. Wastewater treatment costs will be significantly reduced if organic waste is removed from the water before treatment.

Efficient use of resources and cleaner production in frozen pangasius fillet processing to reduce wastewater focus mainly on reducing the amount of solid waste released into the sewage flow.
Measures to reduce solid waste being released into the sewage flow:

- place baskets in production areas so workers can collect solid wastes which can be reused as by-products instead of being discharge into the sewers

- vacuum clean the fish and collect blood and viscera in a filtering funnel instead of discharging these organic loads into the sewage system
- install filtering tools at sewage holes in workshops to prevent solid waste from flowing into sewage mains. Install a fat trap in the sewer (if possible)
- use dry cleaning techniques where possible by scraping and rubbing equipment before washing, cleaning with an air gun and scrubbing down the exposed parts of the floor with rubber brooms
- separate liquid sewage with a high pollution load and pre-treat before discharging it into the sludge conditioning reservoir of the central treatment system

2.5.4 Electricity reduction

Factories in the pangasius industry use a large quantity of electricity and heat. The level of electricity consumption in different companies varies significantly, indicating a high potential for electricity savings. Practical experience from pangasius processing factories has shown that it is easy to save 5%–25% of the energy currently being used in this sector by applying simple measures such as the following:

- establish the energy management system ISO 50001, with an energy saving potential up to 3%–5%
- review and select the most efficient operating process, disseminate information and provide training on the process
- conduct an energy audit, potentially saving up to 3%–5%
- implement Total Productive Maintenance (TPM), potentially saving of energy of 10%–20%.
- install automatic machine lubrication, potentially saving up to 7.5%
- use rooftop solar energy

3. Opportunities for resource efficiency and cleaner production (RECP)

This chapter describes the steps in the frozen pangasius production process and the specific resource efficiency and cleaner production options that are applicable.

3.1 Frozen pangasius fillet processing factories

The production process includes the technological steps summarised in Figure 5.

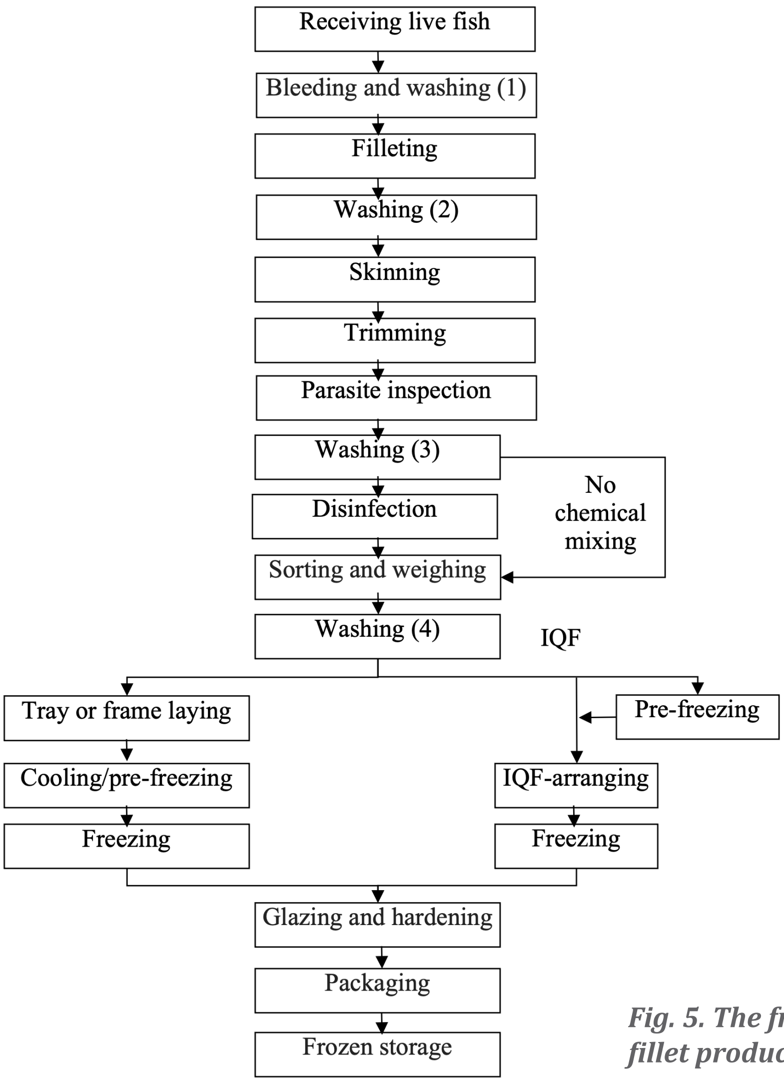


Fig. 5. The frozen pangasius fillet production process steps

3.1.1 Receiving live fish

Raw live fish are transported from the fishing/aquaculture area to the production factory by boats equipped to keep the fish alive (e.g. well-boats). On the wharf they are put into specialised plastic containers and then quickly transferred to the receiving area by conveyor belts or small trucks. At the receiving area for quality inspection, the declaration of origin + antibiotic test report is completed.

Input – output of the step

Fresh live pangasius

↓

Receiving → - Non-targeted species and dead fish
- Spilling water

↓

Bleeding - Washing 1

Environmental issues: water spilling during transportation may cause foul odours and pollute the environment

RECP opportunities:

- Collect non-targeted species and non-live fish (fresh) to be prepared as food for the workers
- Carefully transport the fish to avoid spilling water into the roads
- Do not open faucets completely
- Immediately repair leaky/broken faucets

3.1.2 Bleeding – Washing (1)

After weighing, the fish are killed by cutting the gills/fauces (the arched opening at the back of the mouth leading to the pharynx), then put into a sink to bleed. The purpose of bleeding is to whiten the flesh; they are then thoroughly washed again to rinse off all remaining blood.

This step takes from 10 to 20 min.

Input – output of the step

Live pangasius 100 kg

↓

ashing water
lorine → Bleeding – Washing 1 → - Fish blood: 1.4
- Wastewater

↓

Fish carcass: 98.6 kg

Environmental issues: the wastewater from the processing plant contains fish blood with high levels of biochemical oxygen demand (BOD), which causes foul odours and can pollute the environment.

RECP opportunities:

Water:

- Optimize the water supplying for the tanks to avoid of water waste
- Control the master valve or install extra valves (diameter = 3 mm) to limit water flow to faucets to 5–7 l/min
- Use high-pressure sprayers to wash the workshop floors, tanks, etc.

Electricity:

- Use LED bulbs instead of older technology bulbs (such as incandescent, halogen, fluorescent, etc.)
- Switch off lights when not in use
- Electrical cabinets must have watertight gaskets, and must be checked often to ensure there is no electrical leakage

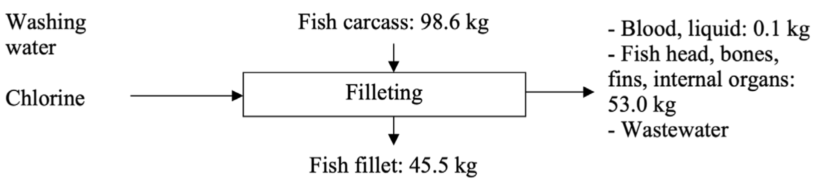
Waste:

- Collect fish blood to use for production of by-products such as fish blood meal

3.1.3 Filleting

With a specialised knife to fillet the fish, the meat is separated from the fish body on both sides, and the head and internal organs (viscera) are removed under continuously running water. The fish must be handled carefully to avoid rupturing internal organs or leaving bones in the flesh.

Input – output of the step



Environmental issues: Using large quantities of water creates large quantities of wastewater, which contains fish blood and viscous liquids, and thus high levels of BOD that easily cause foul odours and pollute the environment.

Large amounts of solid waste: the liquids draining from solid waste can cause environmental pollution.

RECP opportunities:

Water:

- Optimise water flow from faucets to consume less water when washing the fillets
- Use a high-pressure hose sprayer to wash the workshop floor and tanks, etc. (do not use soft hoses)

Electricity:

- Use LED bulbs instead of older technology bulbs (incandescent, halogen, fluorescent, etc.)
- Switch off lights when not in use
- Electrical cabinets must have watertight gaskets, and must be checked often to ensure there is no electrical leakage

Waste:

- Collect solid waste for pangasius by-product factories to produce fish meal and fish oil (or to use as animal feed)
- Collect solid waste to produce useful and edible by-products:
  - Fish heads are used to process crispy fried jaw cartilage and head bone for hot pot cooking

  - Fish bones: fish scraps and bones are used for hot pot cooking or producing seasoning powder

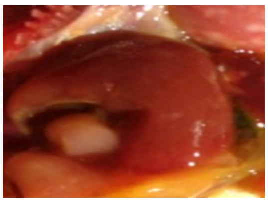
  - Fish stomach: to be fried and stuffed with meat

  - Fish bladder: prepared with a roux (flour + fat cooked together) or used to make gelatine

  - Fish belly: cooked shumai (dumplings)

  - Fins: to prepare crispy fried fins

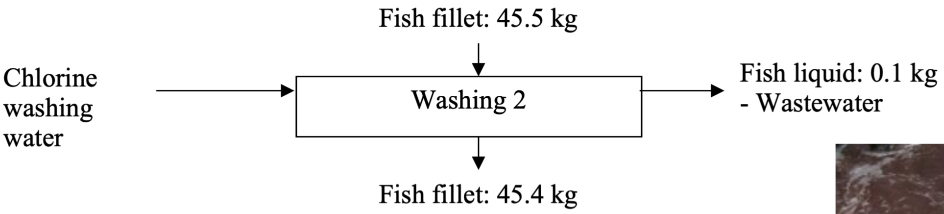
  - Fish liver: for prepare fish liver pâté

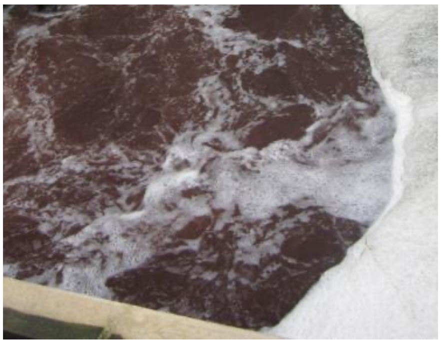



3.1.4 Washing (2)

Wash fish pieces in two sinkfuls of water, stirring by hand to remove all foreign matter, blood, slime and other impurities. Use clean water at temperature of 4–10 °C with a chlorine concentration of 10 ppm. Up to 50 kg of fish may be washed before changing the water.

Input – Output of the step





Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

RECP opportunities:

Water:

- Optimise the amount of washing water
- Do not allow water in the washing tanks to overflow
- Use high-pressure sprayers to wash the workshop floor and tanks

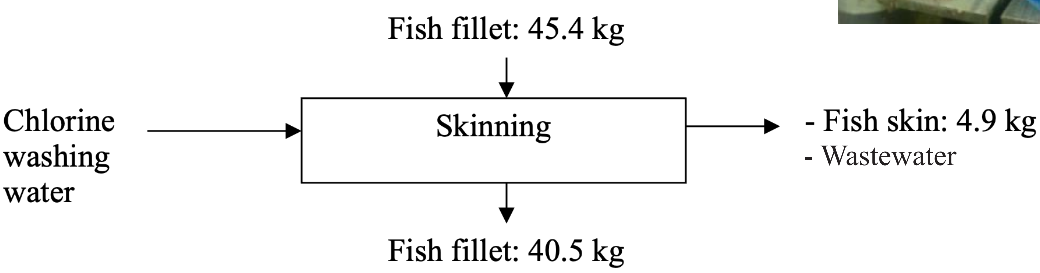
Electricity:

- Use LED bulbs instead of old-technology bulbs
- Switch off lights not in use
- Electrical cabinets must have watertight gaskets, and must be checked often to ensure there is no electrical leakage

3.1.5 Skinning

Use a knife or peeler to remove the skin. The correct technique is to gently manipulate the fillet after skinning so as not to cut or tear the fish meat. Temperature of washing water ≤ 8 °C, chlorine concentration 10 ppm.

Input – Output of the step

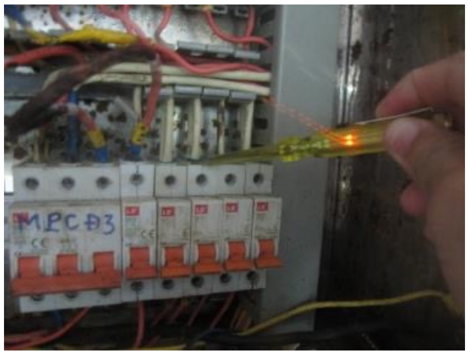


Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

RECP opportunities:

Water:

- Optimise the amount of washing water
- Use high-pressure sprayers to wash the workshop floor and tanks



Electricity:

- Use LED bulbs instead of old-technology bulbs
- Switch off lights not in use
- Electrical cabinets must have watertight gaskets, and must be checked often to ensure there is no electrical leakage

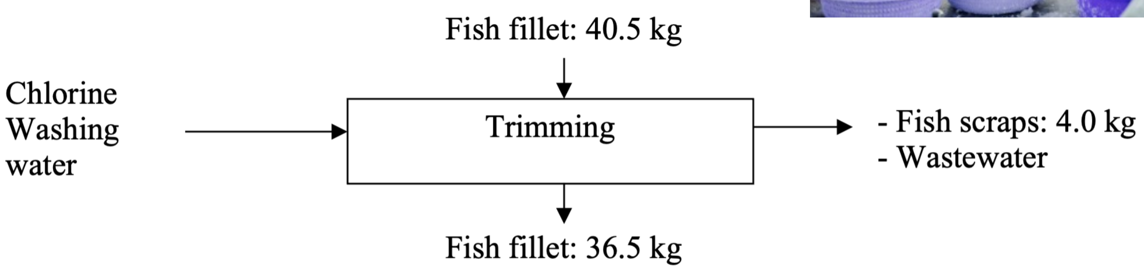
Waste:

- Collect fish skin to produce by-products such as snacks and gelatine.

3.1.6 Trimming

The trimming step removes the red muscle and fat just under the skin of the fillet. The fillet after trimming must be clean of red surface muscle and fat layers and without cuts or tears, it must be boneless, and the surface of the fillet must be smooth. Fillet temperature ≤15 °C

Input – Output of the step



Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

RECP opportunities:

Water:

- Optimise the amount of washing water
- Do not allow water in the washing tanks to overflow
- Use high-pressure sprayers to wash the workshop floor and tanks

Electricity:

- Use LED bulbs instead of old-technology bulbs
- Switch off lights not in use
- Electrical cabinets must have watertight gaskets, and must be checked often to ensure there is no electrical leakage

Waste:

- Collect fish scraps to use as food or to produce by-products

3.1.7 Parasite inspection

Each fillet must be visually inspected for parasites on a table with neon lights to ensure there are no parasite on fillets. Fillets with parasites must be rejected. QC check every 30 min.

Input – Output of the step

Fish fillet: 36.5 kg
↓
[Parasite check]
↓
Fish fillet: 36.5 kg

3.1.8 Washing (3)

The fish are washed through 2 sinkfuls of clean water at ≤ 8 °C. Gently hand-stir the fillets. Wash no more than 200 kg of fish in any single batch of clean wash water.

Input – Output of the step

Fish fillet: 36.5 kg
↓
Chlorine washing water → [Washing 3] → - Fish liquid: 0.1 kg
↓
Fish fillet: 36.4 kg

Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

RECP opportunities: see Washing (2), above

3.1.9 Disinfection

After the 3rd washing, weigh the fish and put them into the mixer: 100–400 kg/batch depending on the size of the mixer. Then add the disinfectant solution (scale ice (flake ice) + salt + chemicals + cold water at 3–7 °C) in a 3:1 ratio of fish:chemical solution.

- Temperature of the chemicals + water solution, 3–7 °C
- Mixing time is at least 8 min and no more than 40 min.
- Fish temperature after mixing < 15 °C

Chemical solution (as stipulated by MoIT): The chemical solution used depends on the final destination market where the product will be exported.

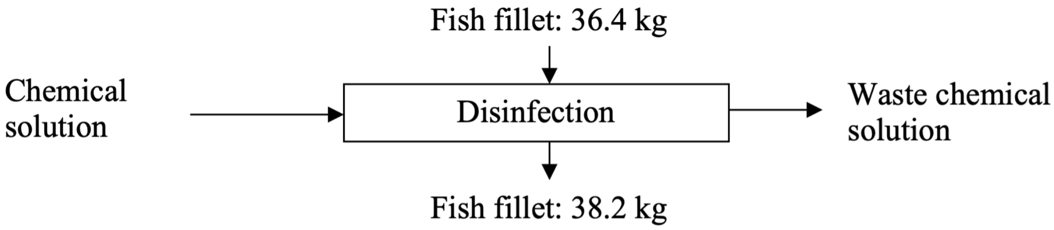
For the EU market: dilute 100 l of solution, composed of:

- Chemicals SP-800: 1.4 kg
- Chemicals NF-400: 2.0 kg
- Water: 70 l
- Ice water: 28 kg
- Salt: 0.25 kg
- Temperature: 3–7 °C

For other markets: dilute 100 l of solution, composed of:

- Chemicals MTR 80P: 1.0 kg
- Chemicals MTR 79: 2.0 kg
- Water: 70 l
- Ice water: 28 kg
- Salt: 0.25 kg
- Temperature: 3–7 °C

Input – Output of the step



Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

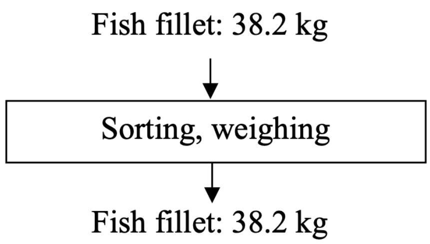
RECP opportunities:

- Optimise chemical mixing time to increase product weight as required (% water in the product) per customer instructions.
- Automatically lubricate the bearings of the chemical mixer

3.1.10 Sorting and weighing

Fillets are sorted by size: 60–120, 120–170, 170–220, >220 (grs/piece) or 3–5,5–7,7–9, 4–6, 6–8, 8–10, 10–12 (oz/piece). The sorting operation must be carried out rapidly to ensure that fish temperature does not exceed 15 °C. Fish are sorted according to size and weight as requested by customers.

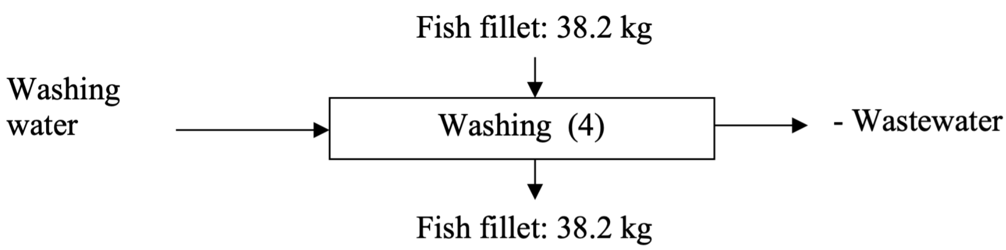
Input – Output of the step



3.1.11 Washing (4)

Fillets are washed in a clean water bath at ≤ 8 °C, and gently stirred/flipped over by hand. Wash no more than 100 kg of fish per change of water.

Input – Output of the step



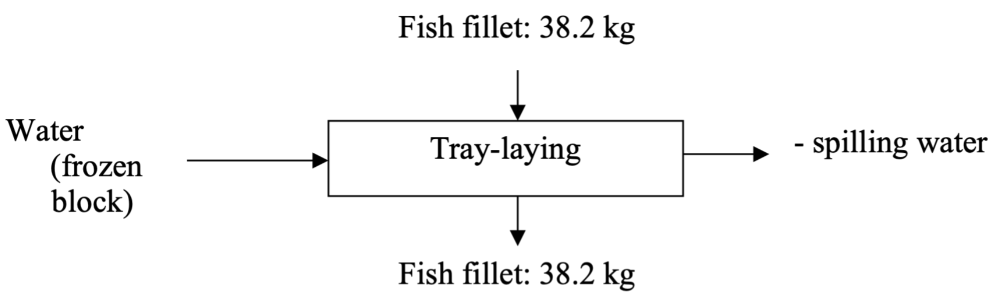
Environmental issues: Wastewater contains fish blood and viscous liquids with high levels of BOD, causing foul odours and polluting the environment

RECP opportunities: See Washing (2), above.

3.1.12 Tray or frame laying/IQF preparation

- Frozen blocks: after being washed and drained, the fillets are then placed into blocks on trays or in frames of 3, 4, 4.5, 5 kg
- Individually quick-frozen (IQF) products: products are stacked one at a time in a single layer on the conveyor belt
- All fillets must be the same size and type

Input – Output of the step



Environmental issues: Spilling water makes the workshop floor dirty.

RECP opportunities:

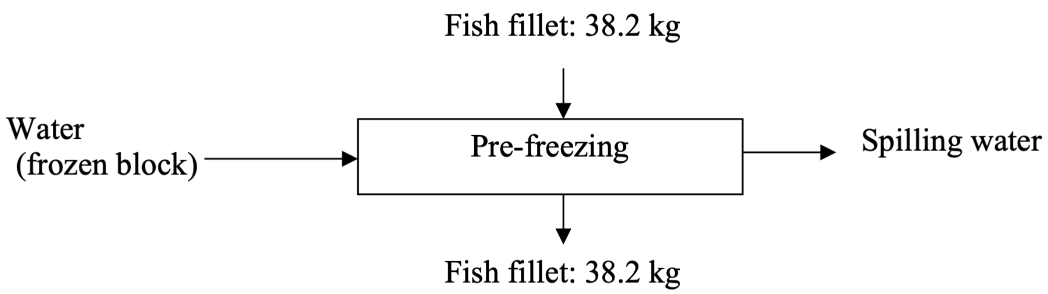
- Care must be used to avoid breaking the frozen fillets
- Correct size of tray must be used (frozen block)

3.1.13 Cooling and pre-freezing

If fillets have not been frozen immediately after being formed into blocks, they must be pre-frozen at a specified temperature for a certain duration. Products must be pre-frozen before entering frozen storage, and the pre-freezing temperature within the cooling storage place should be maintained at -1 °C to -4 °C, with cooling time no longer than 4 hours.

Pre-freezing temperature: -1 to -4 °C, cooling time: ≤ 4 hours.

Input – Output of the step



Environmental issues: Spilling water make the workshop floor dirty.

RECP opportunities:

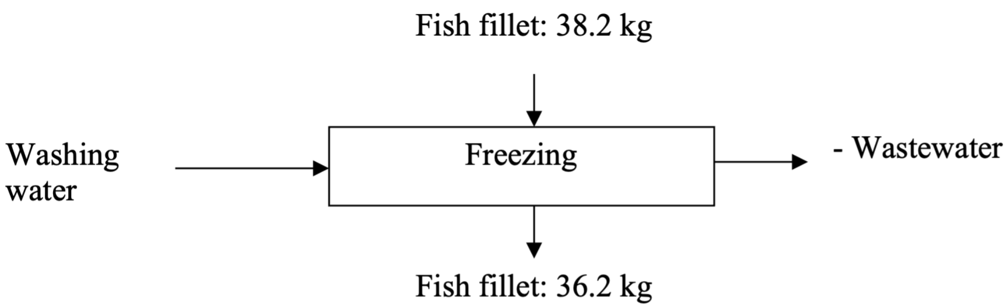
- Care must be used to avoid breaking the frozen fillets
- Correct size of tray must be used (frozen block)
- The pre-freezing chamber must be well insulated.
- Close the pre-freezing chamber when not putting in or taking out products

3.1.14 Freezing

After pre-freezing, fillets will be frozen for storage.

- The contact freezer must be operated until there is a thin layer of ice on the plates, then the fillets are loaded for freezing. Freezing duration is less than 3 hours. Internal temperature is -18 °C. When the fillets are completely frozen, they will be detached from the trays by pouring glazing water on the tray surface.
- For IQF: put the product into the chamber when the temperature is -45 °C. The freezing duration is 10-15 min according to size of the products (capacity is 500–750 kg/h). Fillets must gently be laid flat on the conveyor belt.

Input – Output of the step



Environmental issues:

- Using large quantities of water to wash the freezer (contact freezer) or the belt (IQF freezer) creates large quantities of wastewater.
- Refrigerants (NH3) may be leaked, polluting the workshop.

RECP opportunities:

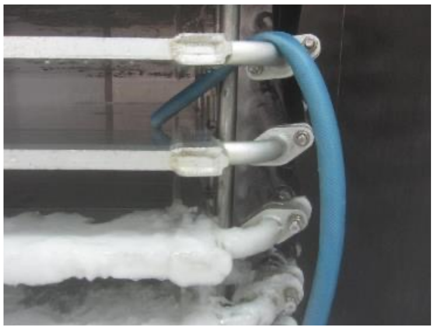
Water:

- Use small faucets (with proper flow) and control the time needed to defrost the contact freezer. Large faucets and long defrosting times waste water.
- Optimise the water volume so that it is just enough to defrost the IQF freezer (do not open the faucet completely).

Freezer:

- Optimise the time to start the freezer to closely link with the previous steps, and turn on the freezer only when the product is nearly ready. Do not start the freezer too early; do not overload it.
- Optimise the temperature setting for the IQF freezer: when the product temperature is lower than -20 °C when coming out of the final IQF preparation step, the temperature of the IQF freezer should be optimised. Without changing any other IQF system parameters (e.g. product quantity, conveyor speed), increase evaporator temperature by 1 degree increments, and monitor the temperature of the frozen product. When the product temperature starts to rise, lower the temperature by 1 degree increments to reach the optimal operating temperature. For example: if the temperature is set at -45 °C, gradually increase the temperature to -44, -43 up to -37 °C7. At -37 °C, when product temperature begins to rise, lower the temperature to -38 °C (this is the optimal operating temperature). Each increased degree over -45 °C will save 2% in refrigeration energy.
- Do not leave products in the IQF freezer.
- Always operate the IQF freezer at full load, never with partial loads.
- Frequent maintenance for the IQF freezer, and ensure that the door is always closed. Immediate repair broken doors that show large gaps.
- If possible, invest in newer IQF freezing technology in which the freezing line is automatically controlled by a temperature inverter.

Gaseous emissions: Frequent maintenance for freezers; repair any refrigerant leaks.



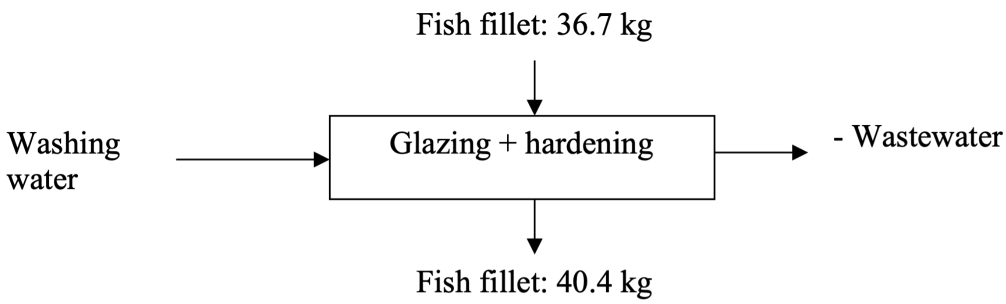
3.1.15 Glazing and hardening (2nd freezing)

Glazing is the application of a layer of ice to the surface of a frozen fish product. After products are glazed, they are unblocked with water applied to the bottom of the mould/plates to separate and pack the fillets. The fillets must be handled carefully to avoid breakage.

- Manual fillet surface glazing: dip each basket of weighed fillets into a barrel/bucket of very cold water with a temperature of -1 to -4 °C depending on the rate of surface freezing to adjust the time needed to glaze the fillets..
- Automatic IQF surface glazing: fillets travel along the conveyor belt from the IQF step through to the continuous freezing tank.
- Glazing rates are 10%, 15%, 20%, 25%, or 30% according to requirements of the market/customer.

2nd freezing: after the surface has been glazed, the product runs through a second freezing step to ensure that the core temperature of the fillets ≤ -18 °C.. The 2nd freezer temperature is -30 – -35 °C.

Input – Output of the step



Environmental issues:

- Washing equipment causes wastewater.
- Leakage of refrigerants (NH3) from the re-freezer causes unpleasant smells in the workshop.

RECP opportunities:

Water: use the high-pressure faucet to wash equipment when production is stopped.

Electricity:

- Set 2nd freezer temperature properly. Do not set the temperature too low.
- Replace the freezer if it is too old.

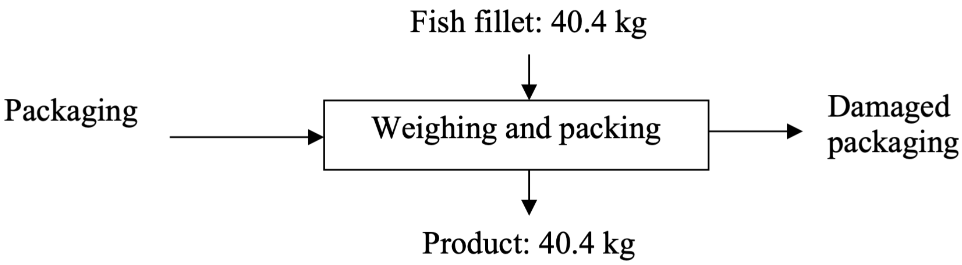
Emissions:

- Frequently maintain freezers, and repair refrigerant leaks.

3.1.16 Weighing and packaging

Products of the same size are put in plastic bags/ cartons according to customer’s requirements. The size, type and specification of the packages depend on different customers. Information on the package is shown in accordance with current regulations of the State of Vietnam, or at the request of customers. Packaging time should not exceed 30 min per freezer.

Input – Output of the step



Environmental issues:

- Using non-environmentally friendly plastic packaging

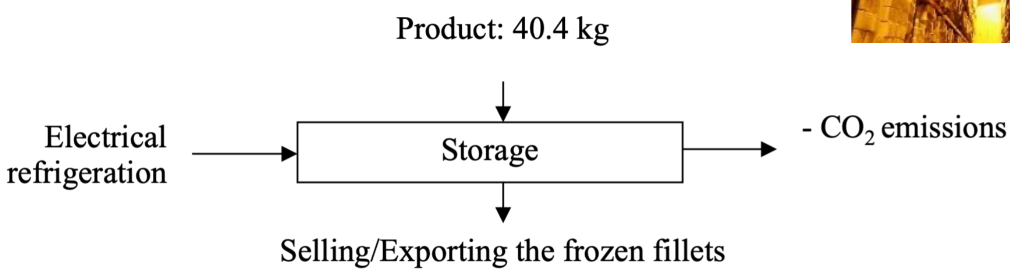
RECP opportunities:

- Designing a more attractive packaging
- Using environmentally friendly plastic packaging (to reduce use of/eliminate plastic bags)

3.1.17 Frozen storage

Finished products must be kept in cold storage at temperature -20 °C ± 2 °C, and sorted in order.

Input – Output of the step



Environmental issues: Use of refrigeration energy to preserve the products for a long time will emit high levels of CO_2

RECP opportunities:

- Set frozen storage temperature at -20 °C ± 2 °C. Do not set the temperature too low: for every one degree C decrease in temperature, power consumption increases by at least 2%.
- Maintenance: frequently defrost the evaporator.
- Optimise defrosting time: Different evaporators in different positions in the cold storage require different defrosting times. Normally, the inside evaporator takes only one-third as long to defrost as the evaporator next to the door. Workers often set the same temperature for all evaporators, which causes high energy losses. Setting different temperatures for different evaporators can save up to 23% in energy.
- Replacing the resistance by the hot gas defrosting method for the evaporators.
- Arranging the products neatly on the shelves, as this avoids product damage

- Immediately repair broken cold-storage doors. Ensure that all doors are always closed. When the doors are opened, energy loss is very high (16–18 kWh/1 m2 of open door), and the cold compressor must operate longer, and will result in a shorter lifespan for cooling equipment. In addition, cold storage is humid, and ice damages the products, causing high economic loss.
- Consider installing extra equipment to maintain automatic opening-closing during storage import and export.
- Replacing the high pressure 250W bulbs with cold 40W LED bulbs.
- If the company has many storage units, consider consolidating the products in the under-loaded cold storage units into one and disconnecting the units not in use. If the company has only one storage unit, divide it into several compartments (or lower the ceiling to decrease storage height) to reduce frozen volume area for when the unit is under-loaded.
- Develop new cold storage units if the current ones are too old and dilapidated (and thus causing high energy losses).

3.1.18 Electrical refrigeration system

Electrical refrigeration provides liquid refrigerants for frozen machines and equipment in the processing plants. The electrical refrigeration system includes: a cold compressor, condenser + fan (for high-capacity refrigerant compressors), condenser + cooling tower (for small-capacity refrigerant compressors), water pumps, refrigerant pumps, and oil pumps.

An electrical refrigeration system diagram is provided in Figure 6.

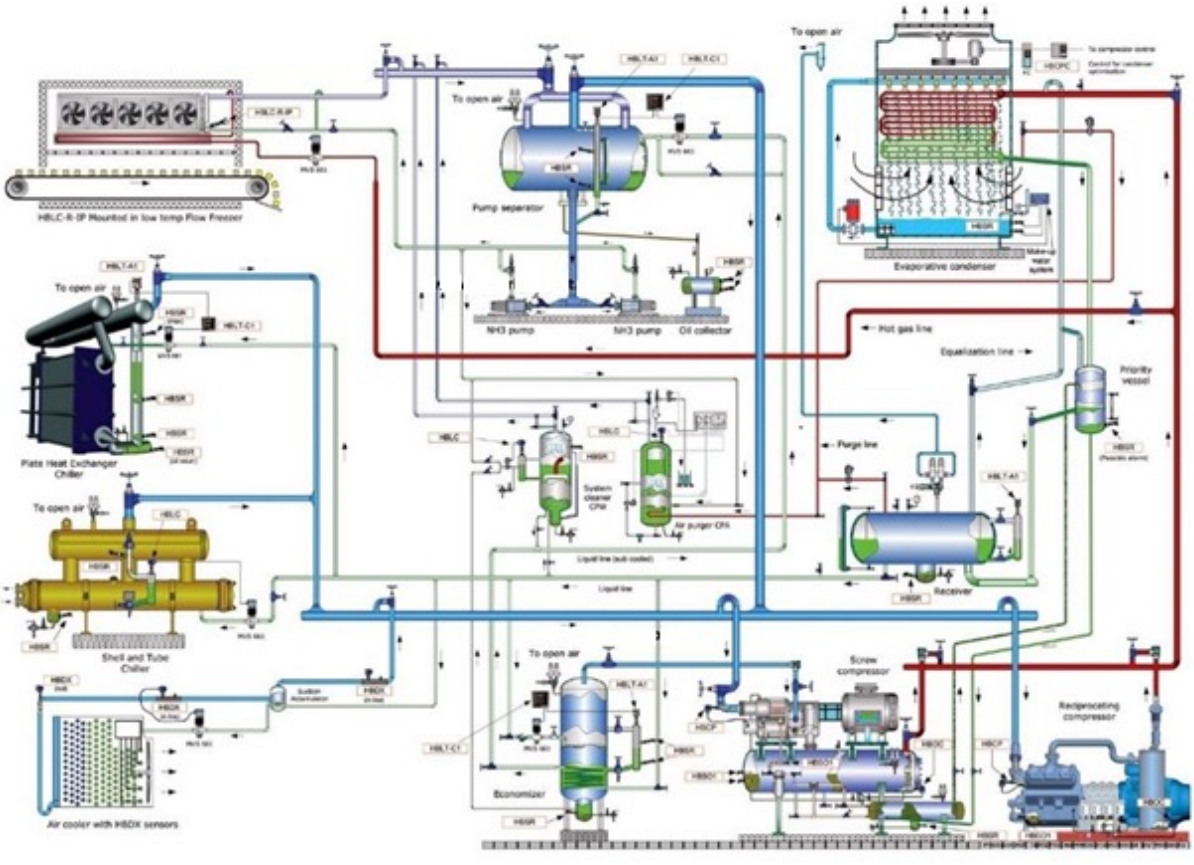
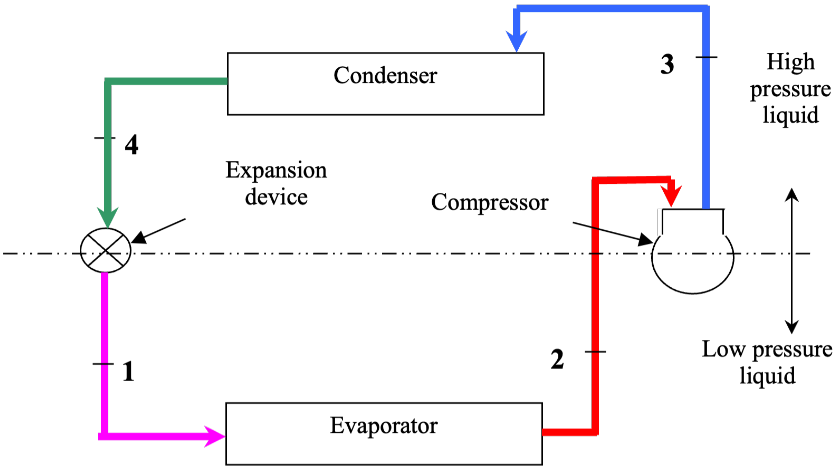


Fig. 6. The electrical refrigeration system (source: HB Products)

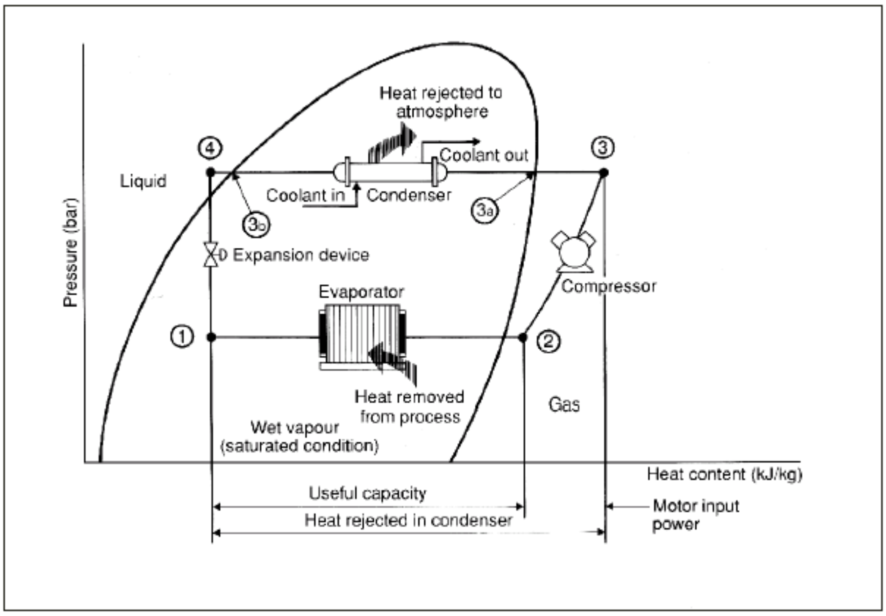


Source: VNCPC

Fig. 7. The vapor compression refrigeration cycle

The refrigeration cycle works as follows:

- 1 > 2 Low pressure liquid refrigerant in the evaporator absorbs heat from surroundings, usually air, water or other liquids. During this process, the refrigerant changes from liquid into gas and will be overheated at the evaporator outlet.
- 2 > 3. The superheated steam is moved to the compressor, where the steam pressure increases. The temperature also increases because some of the energy put into the compression has been transferred to the refrigerant.
- 3 > 4 High pressure overheated gas goes from the compressor to the condenser. The first part of the cooling process (3-3a) de-overheats the gas before it returns to liquid form (3a-3b). This process normally uses air or water for cooling. At the liquid tank and the pipe system, the temperature is further reduced (3b - 4), and the refrigerant solution will be pre-cooled before entering the expansion device.
- 4 > 1 After having been pre-cooled with high pressure, the liquid enters the expansion unit, and this unit will help reduce the pressure of the liquid pressure and adjust the liquid flow into the evaporator.



Source: Department of Energy Efficiency of India, 2004

Fig. 8. The refrigeration cycle with pressure change

The condenser must be able to discharge the combined heat input of the compressor and the evaporator. In other word, (1 - 2) + (2 - 3) must be equivalent to (3 - 4). There is no heat loss or recovery through the expansion device.

Environmental issues:

- The energy required for refrigeration represents a large quantity of electrical power (about 80% of total electrical consumption in the frozen fillet processing plant), which emits large quantities of CO_2.
- The system consumes large quantities of water for cooling (water evaporates during the compression-condensation process); and hard (alkaline) water and concentrated dissolved salt from the condenser are periodically discharged, potentially polluting the environment.

Energy losses and RECP opportunities:

1. **Ineffective energy management** leads to high energy consumption. This can be addressed by:

   - developing the energy management system ISO 50001 that can save 3–5% in energy use
   - implementing energy audits
   - swapping the unnecessary load and intermittent processes to off-peak hours
   - switching off unnecessary energy devices during peak hours
   - operating the factory's generator or diesel generator during peak hours
   - installing sub-transformers near the workshop to reduce the power loss over cables
   - identifying the under-loaded transformers and redistributing the load to optimise energy use
   - regularly maintaining the internal power network, including joints, contacts; checking for electrical leakage; replacing the old (broken) compensation capacitors; avoiding phase loss
   - installing the compensation capacitor at the workshop distribution board or at the high capacity motor instead of at the position of the transformer

2. **High/low voltage:** the standard voltage needs to be maintained at the load with fluctuation of ± 5% (± 2.5% is the best). There will be a voltage drop during transmission of electricity from the transformer to the load that causes a power loss. The maximum allowable voltage drop is 2.5%. If it is higher than 2.5%, it means that the cable is too small and must be upgraded .

High voltage causes overload, with the result that the efficiency and $\cos\varphi$ of the motor drops sharply, while the starting current and the rotary torque increase rapidly. When supplied voltage is 10% higher than the standard, the following losses will result:

- 3-phase electrical motor, air conditioners, compact fluorescent lamps (tube lamps), halogen lamp, and mercury lamps will increase their power consumption by 1–2%, 5%, 8.1%, 17%, and 20% respectively
- compact lamps will not increase their power consumption, but their lifespan will be reduced by 45% (faster burning out)
- electronic devices (computers, photocopiers...), refrigerators, and freezers will increase their power consumption by 1%, 5% and 10%, respectively

Low voltage causes a high loss for RI2 cable (due to the high amperage while the same power is used), overheated motors, and tremendously reduced productivity. When supplied voltage is 5% lower than the standard, the following losses will result:

- the cable RI2 loss will increase by nearly 12%
- 3-phase electrical motors will increase their power consumption by 2–4%
- the starting current of the induction motor and the rotary torque will decrease, increasing the possibility of motor overload by at least 10%
- a 5% increase in motor temperature will cause the motor to break down faster, and motor life will decrease by 50% for every 10 °§C temperature increase
- motor lifespan will be reduced by 50% for every 10 °C increase); incandescent lamps, fluorescent lamps, and other lamps decrease their brightness by 20%, 5%, and 15%, respectively

3. Electrical leakage: Electrical leakage in frozen seafood processing plants is very common: over 90% of seafood companies have electrical leakage with measured voltage between the wire sheath and the wire. neutral is 30-210V. Electricity loss due to leakage costs 200–400 million VND/year. The risk of electrical accidents in the companies is very high.

Electrical leaks occur in seafood plants because they often use NH3 as a refrigerant. During the production process, there may be a leak of NH_3 gas at the valve or flange. Non-condensable gas must periodically be purged, and the NH_3 also leaks out. In addition, repairing the refrigeration compressor/equipment also emits NH_3. When the air is humid, NH_3 will react with steam into NH_4OH and cling to the wire sheath together with other impurities and dirt. Over time, the wire sheath takes on a layer of humid dirt and becomes conductive. The wires are usually located on iron shelves or directly on the floor of the wire cracks, so electricity will be transmitted from the top of the code at the circuit breaker (aptomat) to the ground through the wire sheath, causing the power loss. Thus, electrical leakage is low on sunny days due to the dry wire sheath (its low conductivity), but high on rainy/humid days or humid nights because the dirty layer on the wire sheath is very humid and the electricity conductivity is still good.

Identification of electrical leakage: using an electrical tester to check the wire sheaths (see photo above). If the tester is red, there is an electrical leakage; using V-A pliers to measure the voltage between the wire sheath and the neutral wire: the higher the voltage, the greater the power loss.

Solutions:

Solution 1 - New investment: The best way to prevent electrical leakage is to re-install the power transmission system (investing in new wires or reusing the old ones) overhead (not located in trenches underground). However, this solution is very expensive, and will also entail production downtime while the entire internal electricity network is being renovated.

Solution 2: The company handles the problem by itself, by cutting off the power to ensure the electrical safety (the wire sheath has no electricity), or by using water to wash away the dirt on the wire sheath, which will completely solve the electric leakage. If water does not work, RP7 can be sprayed on the wire sheath and wiped off (the RP7 will not damage the wire sheath). After washing and when the sheath is dry, a cloth with insulating oil can be used to polish the sheath to strengthen the insulation. In some cases, the insulating layer of the wire sheath will be deteriorated, but if the company does not want to change the wire due to high cost, it can be painted with an additional insulating layer on the wire sheath after it has been cleaned and is dry.

Solution 3 – Outsourcing. The company can hire the Department of Electricity to maintain the internal electrical transmission system if it is unable to do by itself. The estimated cost is 5–15 million VND/company.

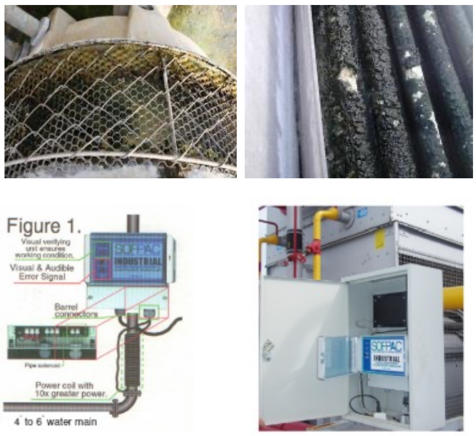
4. Non-condensable air in the refrigeration cycle needs to be eliminated: how to identify non-condensable air in the refrigerants:

- Check the condensing pressure and temperature of the refrigerants coming out of the condenser.
- Comparing with the data in the table of standard temperature/pressure for NH_3. The difference between the two pressures is the air pressure.
- For example: the temperature of NH_3 is 29.4 °C, theoretically the pressure will be 11.71 kg/cm^2. In fact, the pressure meter shows the number of 13.06 kg/cm^2, so the air-caused overpressure will be 1.35 kg/cm^2. The energy loss is 10% and compressor capacity reduces by 5%.

Solutions:

- Enhancing non-condensable air purging in case of high compression pressure
- Investing in an automatic non-condensable air purging system

5. Poor maintenance: build-up of scale/mould in the heat-transfer tubes.



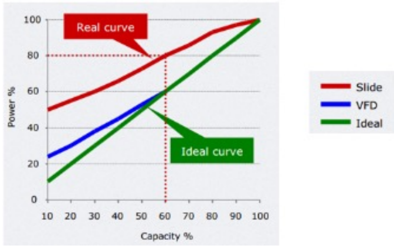
Solutions:

- Strengthening industrial maintenance to ensure the heat exchangers are always clean
- Using chemical products to remove mould
- Investing in the automatic descaling system

6. Condenser fan/cooling pump is always operating at 100% capacity even when demand for cold temperatures is low.

Solution: Install an automatic inverter to reduce power consumption when cold demand is low.

7. The rotary screw air compressor controls the continuously variable load by means of a slider, thus when the load decreases, the coefficient of performance (COP) decreases in the high compression ratio at the fastest.



Solution: Replacing the rotary screw compressor to an inverter to save up to 20% energy.

8. Using the expansion valve to adjust the suction line: PM valves with the pilots of CVP, CVC, CVT, and etc. are usually used to maintain exactly the desired pressure in front of and behind the PM valve. Advantage: this is simple, and can maintain the pressure exactly. Disadvantage: low COP (high energy loss).

Solution: Replace with modern energy-saving expansion valves to save up to 10% of power.

9.The refrigeration compressor is too old, with low COP.

Solution: Invest in a new and more modern refrigeration compression system with high capacity and COP to save up to 20% in energy.

10. The condenser is too old and broken, with lots of dregs.

Solution: Investing in the new condenser to save up to 30–40% in energy.

3.2 Pangasius by-product processing factory

The production process includes the technological steps as summarised below:

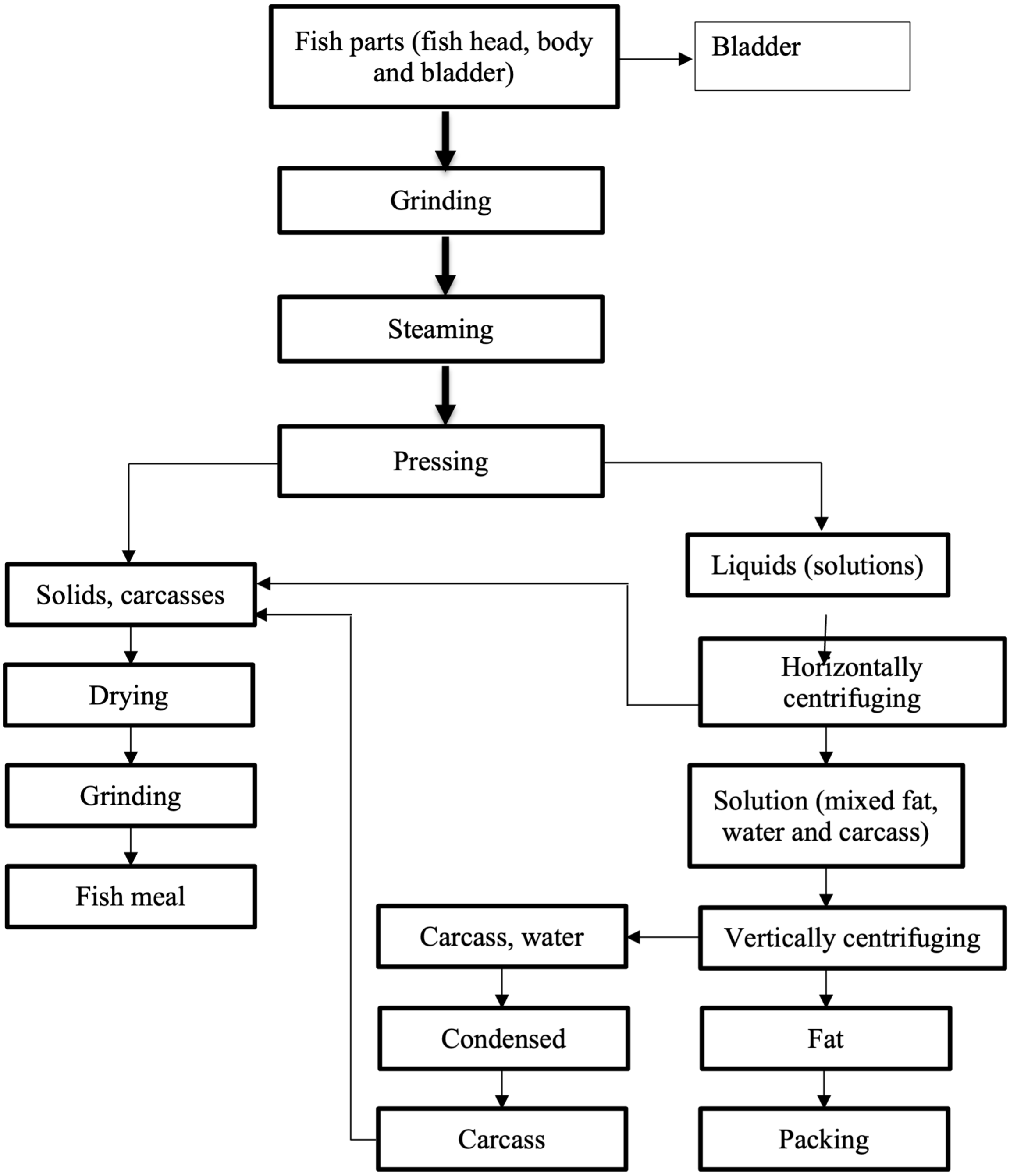
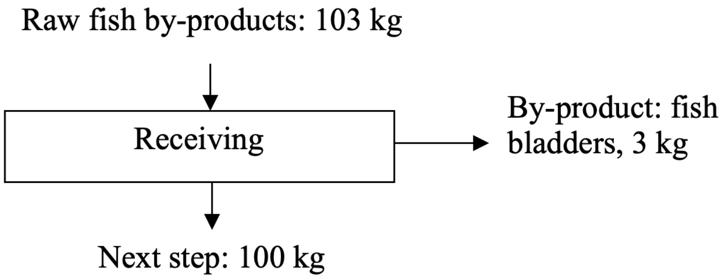


Fig. 9. The technical process in the pangasius by-product processing plants

3.2.1 Receiving raw material

Inputs are by-products, residues such as pangasius/basa heads and bones from the frozen pangasius fillet factories. After receiving the raw materials, sort out the fish bladders manually.

Input – output of the step



Environmental issues: large quantities of fish viscous matter and blood cause foul odours and make the workshop floor dirty.

RECP opportunities:

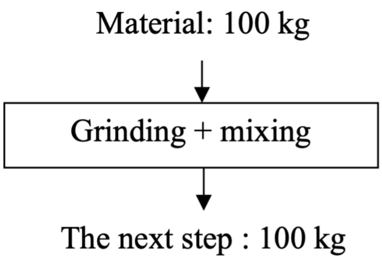
- Collecting fish bladders as by-products as rapidly as possible.
- Sweeping the floor with a rubber brush to remove all solids, then washing using a high pressure hose and nozzle to minimise water consumption.

3.2.2. Grinding and mixing

Grinding to reduce the by-product parts size as required for pressing or mixing with cooked bran and flour. The grinding also increases the digestibility of nutrients and the quality of pressing.

Mixing and homogenising: an even mixture will be achieved after the 3-min of griding. The homogeniser makes it possible to mix a high volume of product prior to final processing, and in particular supports mixing cooking brans, such as those with high levels of oil- or molasses-containing ground grain.

Input – Output of the step



Environmental issues:

- Use of electricity emits CO_2
- There may be spillage of products that pollute the environment

RECP opportunities:

- Using sieves with different sizes for different products
- Installing a compensation capacitor for the grinding and mixing system (as this system often works underloaded)
- Automatically lubricating all moving mechanical parts

3.2.3. Steaming + Pressing + Separating liquid and solid

After grinding and mixing, the mixture will be heated to 80–85 °C in a steamer. This temperature will pasteurise the product and ensure production of more solid and equal-sized pellets for the solid parts, such as fish carcasses.

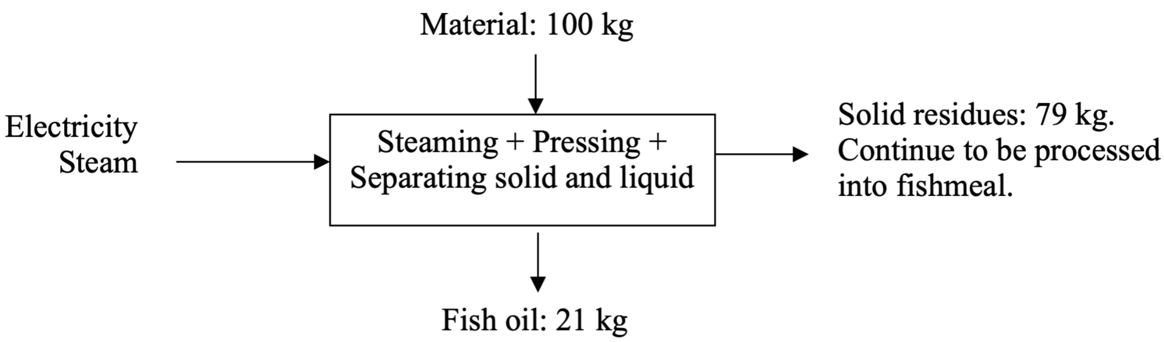
After steaming, the mixture is pressed to separate fish liquid and oil.

The liquid part is horizontally centrifuged into the mixture of fat, water and carcass, and is then vertically centrifuged to separate it into fish-oil products for packing. Fish-oil products are used as raw materials for processing cattle, poultry and aquatic feeds, or are extracted into essential oils for processing as cosmetics and food, and for producing biodiesel oil, glycerol, and Kali Nitrate for fertiliser and lubrication. The solid carcasses from the centrifugation step are collected with the post-pressing solid residues to make fishmeal.

The solid part continues in the processing steps to produce fishmeal.

Fig. 10. The thermal oil boiler system

Input – Output of the step



Environmental issues:

- Use of electric and thermal energy emits CO_2

RECP opportunities:

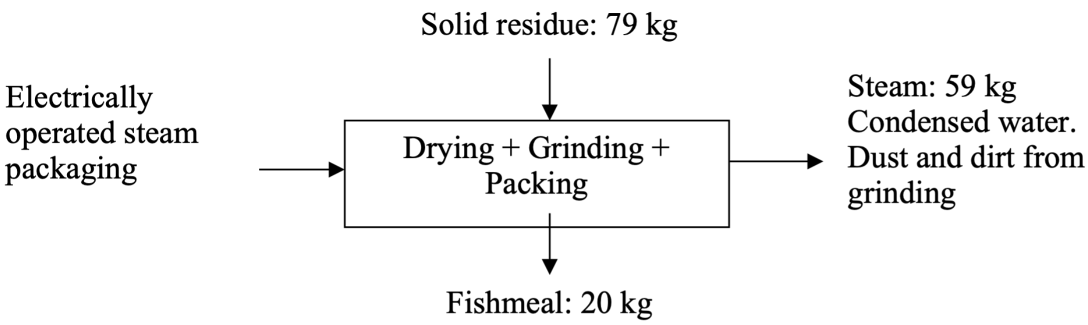
- Improving heat insulation for the steamer
- Installing a compensation capacitor to ensure full loads (as this system often works underloaded)
- Automatically lubricating all moving machine parts

3.2.4. Drying + Grinding + Packing

The solid residues from the pressing step and the solids from the centrifugation step will then be dried. The heat supplied to the dryer is the steam from the boiler in the auxiliary workshop.
After drying and cooling the product, it will be finely ground into fishmeal with a protein level of up to 60%, and it will be used for producing processed animal feed.

Fig. 11. The product packaging system

Input – Output of the step



Environmental issues:

- Use of electrical and thermal energy emits CO_2
- The drying step causes an unpleasant smell.
- High levels of dust and dirt cause environmental pollution.

RECP opportunities:

- Ensuring good thermal insulation for the dryer and steam pipes
- Installing a compensation capacitor for the system (as this type of system often works underloaded)
- Automatically lubricating the moving parts

3.2.5. Boiler

The boiler is a device that helps provide heat from the combustion step for heating or boiling (i.e. the water is either hot or turned into steam). Hot water or steam under pressure will transmit heat to a heat-requiring step. Water is a cheap and useful intermediate to transmit the heat. When water becomes steam, its volume will increase by about 1600 times, creating high pressure. It is important to note that a boiler is a high-pressure machine that must be very carefully, as there are risks involved with this equipment.

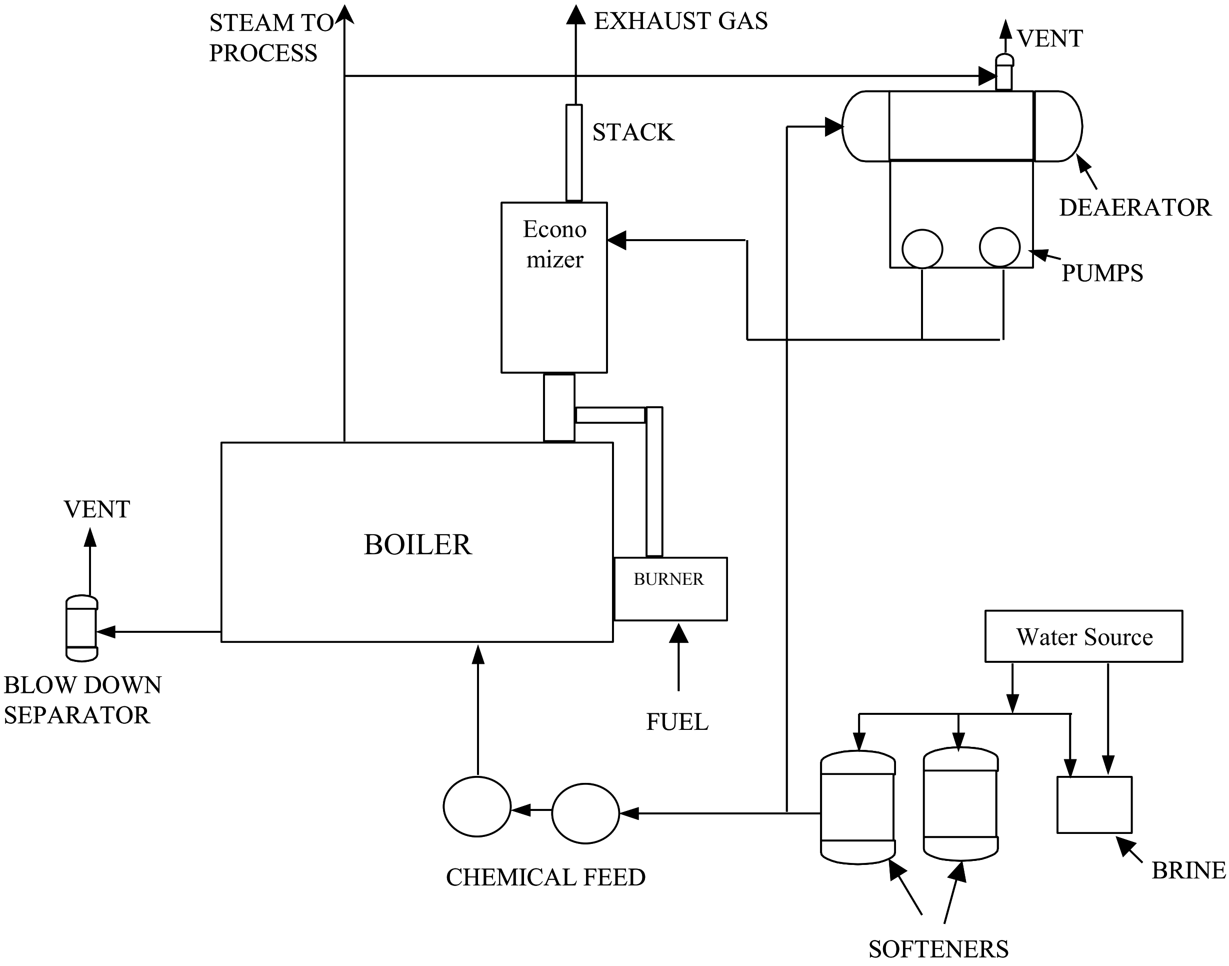


Fig. 12. Boiler Process Diagram

RECP opportunities:

- Setting the temperature of exhaust gas from the boiler as low as possible. A temperature higher than 200 °C will reveal the boiler's potential to recover excess heat, while a decrease of 22 °C will increase capacity by 1%.
- Pre-heating the supplied water via the heat exchanger in which heat is recovered from the boiler represents a 6% increase of the supplied water temperature, which will save 1% in boiler fuel.

- Pre-heat the gas supplied for the boiler as an alternative for pre-heating water. If the temperature of supplied gas increases by 20%, thermal efficiency will increase by 1%.
- Minimize incomplete combustion
- Controlling residual gas: if residual gas decreases by 5%, the boiler's efficiency will increase by 1% (or, if oxygen in the boiler exhaust gas decreases by 1%, the boiler's efficiency will increase by 1%)
- Minimize heat loss caused by radiation and convection with good insulation of the boiler cover
- Automatically (ultrasonic or magnetic) descale the heat pipes (a 3 mm soot layer on the heat exchanger surface can increase fuel consumption by 2.5%. A dreg layer on the water tank wall can increase fuel consumption by 5–8 %)
- Install inverters for the boiler fans
- Control the boiler load: the boiler achieves optimal efficiency only at a load of 65–85 %.
- Decrease boiler pressure when possible to save 1–2% of energy.
- Control automatic blow down: every 10% blow down in a 15kg/cm2 boiler will lose 3% of efficiency.
- Replace the boiler when it becomes too old.

4. RECP – What is it, and how does it work?

This chapter provides specific information on the basic concepts and benefits of resource efficiency and cleaner production in the frozen pangasius fillet processing industry

4.1 What is resource efficiency?

In the past 50 years, human beings have modified planetary ecosystems more rapidly and more profoundly than at any other time in history. This impact manifests itself mainly as a growing demand for fuel, food and clean water. The result of these demands is a huge, irreparable loss of biodiversity in the world.

It cannot be denied that changes in the ecosystem have achieved positive results in people's lives and for the economy: however, these achievements have come at a high price, including the degradation of ecosystems (for the needs of clean water, waste treatment, energy, minerals, and renewable resources), and starvation in some regions. These problems will adversely affect future generations if they are not solved.

The research of Bước đi Tự nhiên Quốc tế shows that there is a paradox here. So while natural resources may be able to meet people's demands sufficiently in the present, in the future our ecosystems will not be able to keep up with the current economic growth rate.

There are two trends that clearly demonstrate that crises are threatening the world's sustainability, including the serious degradation of and increased demand for natural resources and ecosystems. According to the World Wide Fund for Nature (WWF), our earth is facing an 'overload'. We are consuming 25% more of the natural resources than the Earth's renewable capacity. Our lives are relying on an 'eco-credit fund'; however, the more we use this fund, the more difficult will it be to recover the 'ecological capital' already spent.

Strategic actions such as strengthening of resource efficiency and cleaner production (RECP) in companies can bring about more efficient production and a more sustainable future. RECP is an efficient and effective way to reduce waste and cut costs for the waste treatment processes. Reuse of resources can save companies' expenditures because their demand for new resources will be lower. Legal regulations on using natural resources will tighten the use and reuse of resources in the future.

RECP is the continuous application of an integrated strategy on environmental management in the production process in order to increase efficiency and reduce the risks for human beings and the environment. RECP focuses on the sustainability of three factors that are independent but related closely with each other:

- The production process: optimisation of the natural resources use (including raw material, energy, and water)

- Environmental protection: Mitigation of deterioration of the environment and nature
- Human development: mitigating the risks for human beings and communities as well as ensuring development for future generations

4.2 The natural resource indicators

Resource efficiency and cleaner production (RECP) is an integrated and systematic approach for management of raw materials, energy, water, and chemical resources to restrict and mitigate waste and gaseous emissions in the environment in a sustainable and cost-efficient way.

RECP must have solutions to meet human needs while paying attention to ecosystems through increased production efficiency combined with lower resource consumption.

Resource efficiency is measured by reducing resource use and environmental degradation, along with proper management of raw materials, waste, and concomitant emissions per unit of production, trade, and goods and services consumption throughout their life cycles.

For RECP assessment, sustainability indicators as the basis for making important decisions or controlling the implementation progress is a requirement.

Raw materials

Reducing the amount of material used for a product, and/or increasing the efficiency of product recovery per amount of material mean increased resource efficiency. This can be achieved by changes in technology and/or production management.

For a pangasius processing plants, reducing raw materials means reducing inputs such as fish and auxiliary materials (e.g. cartons, plastic, rope/twine, etc.) per frozen pangasius fillet unit, and re-using the waste from fillet processing to produce useful by-products.

Energy

Frozen pangasius fillet processing plants often use a large amount of electrical energy, from 1–3 million kWh/month. In addition, fillet production also requires the transportation of large quantities of raw materials/products over long distances, causing CO_2 emissions. To sum up, a carbon footprint is generated from most human activities, including production and transportation.

A carbon footprint is defined as the total amount of greenhouse gases (GHG) generated by direct and indirect human activities of, expressed as carbon dioxide equivalents (CO_2e).

It is noted that:

- Each kWh electricity will generate 0.913 kg of CO_2.
- Each ton/km of waterway transport will generate 0.01 kg of CO_2.

Water

Water is a special kind of resource. As is well known, the increasing world population and the growing economy require large quantities of water for domestic purposes, agriculture and industry, and this has put pressure on water resources, creating conflicts among users. Moreover, increasing pollution worldwide is also a threat to clean water resources.

Pangasius processing plants use large quantities of water, which is usually surface water (from rivers) or groundwater (from natural springs and drilled wells). In addition, processing plants employ many workers requiring a considerable amount of water for their personal use as well.

The water efficiency index in the pangasius processing plants is calculated as the amount of water used for each production step per product and the amount of domestic water per worker of the plant.

Chemicals

Pangasius processing factories often use fewer chemicals. Normally, the chemicals used inside the processing plant are only disinfectant chemicals and cleaning agents for production equipment; or liquified petroleum gas (LPG) to serve the cooking needs of workers. However, in these factories, there is always a refrigeration system generally using NH_3 or R22 chemicals as the refrigerant.

Depending on their properties, chemical substances can cause various problems for human health such as skin rashes and allergies, as well as physical effects such as fires, explosions, or toxic gas emissions, to name just a few.

Improper storage or control in the use of these substances can lead to environmental and health risks.

Safer production is about using fewer hazardous materials, and in recognising hazards and controlling them. Thus, RECP can reduce the occurrence and harmful effects of technical and environmental accidents. The purpose of the RECP strategy is to identify and raise awareness of chemical hazards in order to provide reasonable solutions that minimise hazards in the production process, as well as to have less impact on local communities.

4.3 Benefits of RECP

How resource efficiency and cleaner production benefits businesses:

- Implementing RECP helps businesses become more cost-effective by
    - reducing raw material, chemical and energy cost
    - reducing waste disposal and treatment costs
    - complying with laws and regulations on waste management and the use of chemicals
- Businesses implementing RECP face fewer environmental and business risks than other businesses, resulting in increased confidence in banks
- The basic tenet of safer manufacturing is to reduce hazards rather than to deal with problems, while managing chemical risks more effectively
- Businesses implementing RECP can certainly improve their image and increase their competitiveness by providing safer and more high-quality products

4.4 Implement RECP at the enterprise

Preparing for the design and production of resource-efficient products is a complex task for many businesses, requiring the involvement of many departments from product design to procurement, manufacturing, sales and maintenance. Therefore, the process needs an integrated approach that is in harmony with the management system of the enterprise.

Figure 13 describes the detailed RECP assessment methodology that has been successfully applied in many industrial enterprises in Vietnam.

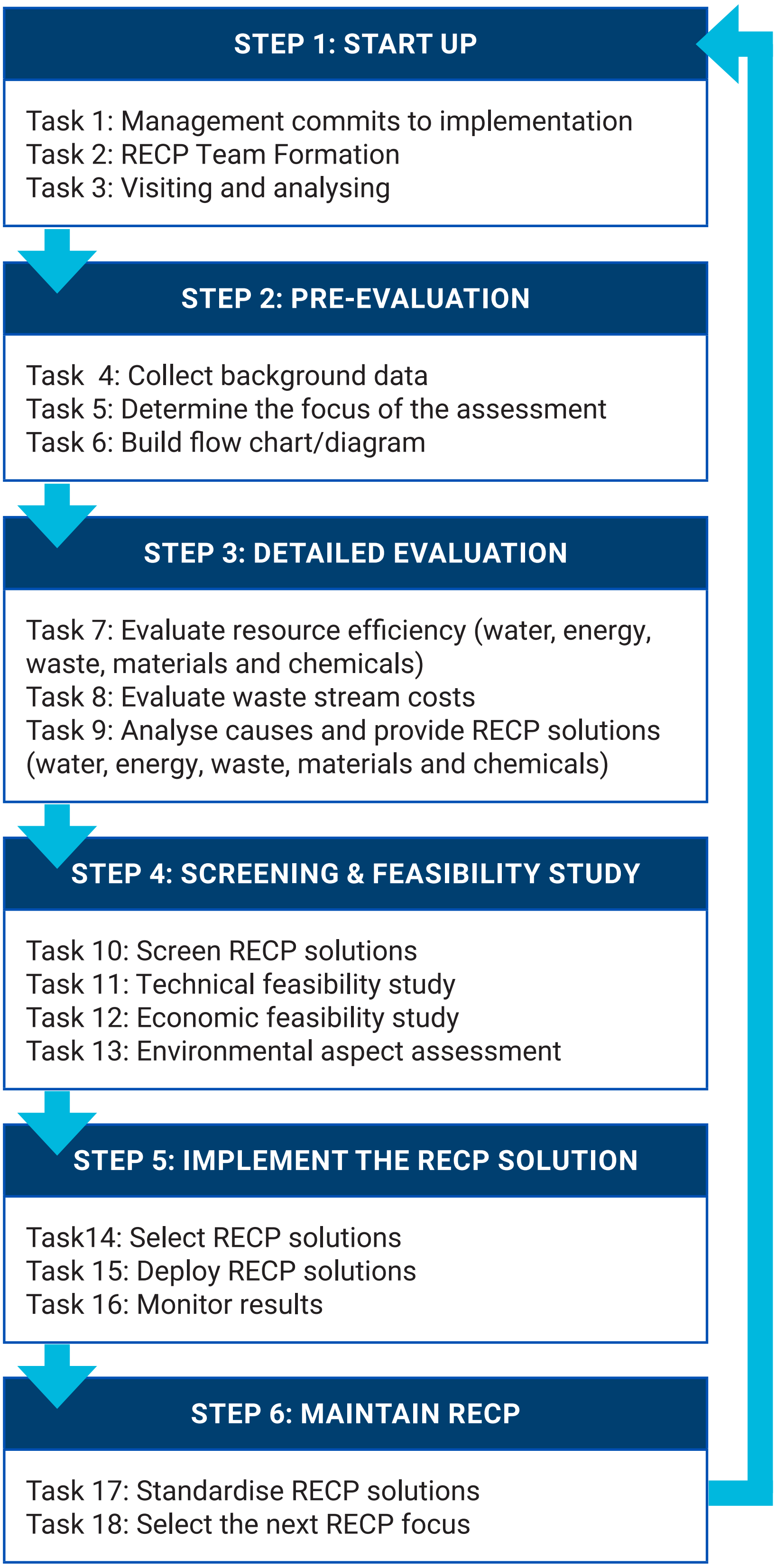


Fig. 13. Evaluation of RECP in enterprises

5. Review of Resource Efficiency and Cleaner Production by topic

This chapter provides a theoretical basis for Resource Efficiency and Cleaner Production analysed under five topics: water, energy, raw materials, chemical safety and waste management in the pangasius processing sector.

5.1 Efficient Use of Water Resources

WHAT: Water Consumption Problems

Water is an essential resource for the economy. All industries must rely on water to maintain and develop their production activities. However, clean water is increasingly scarce, and in the future this situation will get worse and worse. Reducing both the stocks and the quality of water while increasing demand is a significant challenge for pangasius industry businesses, which are already familiar with the concept of clean, abundant and cheap water (river and well water are tax-free; the only cost is the electricity needed to pump it).

Unsafe water has a direct impact on businesses by:

- Reducing the amount of water available for businesses
- Disrupting production and causing financial loss
- Negatively affecting future development and operations
- Causing conflict with local communities and water users
- Restricting specialised industrial activities and investments
- Increasing the cost of water
- Increasing demand for water-saving products and technologies
- Increasing pre-treatment costs to achieve the required water quality
- Increasing the cost of wastewater treatment, in line with increasingly strict legal regulations

It is clear that businesses face many problems arising from scarcer water reserves and lower water quality. Water efficiency is an overarching programme that includes functions, tasks, processes and results to work towards the goal of saving as much water as possible.

Especially for the frozen pangasius fillet industry, water is an important element in product structure (rotating weight gain and surface freezing), and water also plays an extremely important role in processing because of how much washing is necessary, and because it is necessary to reduce high temperatures during processing.

The ultimate goal in terms of water quality is to minimise wastewater and prevent the release of pollutants into the environment. Achieving that goal requires a good supply/wastewater treatment system, which also contributes to increased resource efficiency. The goal of zero wastewater is not feasible for the pangasius processing sector, so the industry can apply other strategies, including safer production, which helps reduce pollution and ensures that the materials mixed in wastewater are properly disposed of and/or are recovered, and that the discharged water is properly treated.

WHY: Saving water benefits businesses

The direct benefits that effective use of water resources bring to businesses are:

- Saving water contributes to reducing water costs due to reduced demand, and also contributes to reducing costs of extraction, pumping, treatment and disposal of wastewater at corporate or public treatment sites
- Saving water brings the opportunity to improve efficiency in other areas
- Saving water will reduce the risk of environmental pollution

Other environmental benefits from efficient use of water resources:

- There is less chance of damage to the sewage system from overloading
- Water pollution is reduced
- There is less need to install water and wastewater treatment equipment
- Efficient use of water resources reduces the requirement for energy in waste treatment

HOW: Implementing a water-saving programme

To effectively implement water resources, businesses should follow the four steps below.

Step 1: Draw a Water Diagram
Make a water flow diagram that describes the use of water from the source, through production processes, machines, buildings and plants, etc., to wastewater treatment.

Step 2: Collect data
After all sources have been identified, water-related uses and emissions need to be quantified for each water stream. It is relatively easy to collect water consumption data because water meters and data are generally readily available and relatively inexpensive.

Step 3: Benchmarks
The process of comparing the performance of one business with others in the same sector is known as benchmarking, or determining and comparing levels among companies to see at what level one's own company performs, so as to strive to become 'the best' in the sector and constantly make improvements.

Step 4: Consider the solution
In the pangasius fillet processing factory, very large quantities of water are used. To reduce water consumption, the first thing to do is to analyse water use carefully, because it may be necessary to install meters on the pipes to monitor the purpose as well as the amount of water used, and to determine water consumption per ton of raw material or finished product.

5.2 Efficient Use of Energy

WHAT: Energy Consumption Issues

Pangasius businesses use a lot of electrical energy, but that's not the problem: the problem is how that energy is consumed.

Using a lot of energy will release carbon and greenhouse gases (GHG) into the atmosphere and/or create harmful wastes. The consequence is global warming and increasing scarcity of energy.

Currently the lack of electricity is a serious problem, and power cuts to factories at peak times are quite frequent. When there are power outages, the scarcity of electricity forces pangasius businesses to choose diesel generators as a source of electricity to maintain cold storage; but diesel costs twice as much as electricity from the national grid. There is thus an urgent need to increase the energy efficiency of the grid, especially given the increasing price of electrical energy in Vietnam over time.

WHY: The benefits of saving energy

Studies have shown that by saving energy businesses can achieve the following benefits and opportunities:

- Capacity-building, in compliance with environmental requirements
- More and better marketing opportunities due to increased energy efficiency

Direct benefits that businesses receive from efficient energy use include:

- Reduce operating costs
- Reducing exposure to risk by reducing dependence on increasingly expensive energy sources
- Enhanced energy security
- Increased reliability of machines and production processes
- Better production line adjustment

Indirect benefits for businesses from the efficient use of energy in their production processes:

- Improved internal effects on employees and their working environment, such as:
  - Improved indoor environmental quality (IEQ) and working conditions
  - Improved employee attitudes.
- Reduction in personnel turnovers
- External enhancement of the management image of the business

Reasons why businesses are hesitant to participate in energy efficiency:

- Lack of knowledge and expertise on energy efficiency
- Lack of awareness about the benefits that efficient use of energy brings
- Failure to take advantage of information resources, tools and training programmes
- Lack of financial and human resources
- Poor long-term planning
- Environmental activities are often defensive in nature to comply with environmental laws and pressure from the community

HOW: Implement an energy efficiency programme

To make efficient use of energy, businesses need to follow these steps.

Step 1: Collect data
Consumption data as well as annual costs should be collected for different types of energy. This data can be obtained from energy bills or from oil and diesel suppliers or from data obtained by the electromechanical or electrical equipment department at the company.

Step 2: Draw a device list diagram
Draw a diagram of devices in the company with corresponding energy consumption data that will show which devices use what type of energy.

Step 3: Record the data
The following points should be considered:

- Will specific energy consumption increase? What are the causes? Which areas are increasing? Does the increase affect total energy consumption? Can energy sources be replaced?
- If specific energy consumption is reduced: is the reduced consumption due to the adoption of specific energy-saving methods? Has the goal been achieved? Or is the decrease due to an alternative energy source?
- Where can the appropriate level of energy use be found? Ask colleagues about normative ('norms') data; ask the device manufacturer.

Step 4: Compare consumption norms
To assess the energy consumption of a business, key performance indicators are very useful. The indicators have a reference value depending on the characteristics of each type of energy that the business uses

Step 5: Make a load profile and analyse it

Step 6: Consider solutions

Measures to take:

- Review and select optimal operating procedures, disseminate and process training
- Carry out an energy audit (if possible)
- Measure and determine the electricity consumption of each production step and production area, and to make a plan to save electricity at each
- Regularly perform industrial maintenance, especially for the refrigeration system

5.3 Efficient Use of Materials

WHAT: Raw Material Challenges

Currently, pangasius businesses are using 1.9–2.5 tons of raw fish to produce one ton of frozen fillets.

The three components of efficient use of materials can be identified as follows:

- Weight reduction during production
- Waste reduction in the production process
- Recycling materials in the production-consumption cycle

WHY: Benefits of efficient use of ingredients

There are many benefits to be gained from improving material efficiency:

- Natural resources are conserved
- Reducing the need for raw materials will reduce the impact of raw materials extraction, including environmental and social repercussions
- Energy is saved, and greenhouse gas emissions are reduced
- Increased material efficiency leads to a reduction in waste materials, a reduction in water and air pollution as well as other negative effects from waste management
- Improving waste collection and recycling efficiency can reduce the amount of waste that ends up in land-fill and water which, in some cases, causes the blockage of drainage systems

HOW: Businesses can improve material efficiency

Material flow analysis is a systematic approach that aims to:

- Give an overview of the materials used in the business
- Determine the starting point, volume and causes of waste and emissions generation
- Establish the basis for assessment and forecasts for future development
- Identify strategies to improve the overall situation

Step 1: Draw a material-flow diagram

- Define the target of the material flow analysis and the parameters to be observed
- Determine the balance range
- Determine the balance period
- Identify the steps in the process

    Define parameters:

    First, a comprehensive input/output analysis will answer the following questions:

    - What materials are used in the business?
    - How many ingredients are processed?

- What is their economic value?
- How much waste is created and how many GHGs are emitted as a result of the production process?

Balanced range: The balance range may cover the entire company or be limited to individual processes. The definition depends on the object of the analysis. First, analyse the entire company to identify possible intervention points and the processes that need to be broken down into steps.

Balancing cycle: Choosing a certain period of time for the balance cycle has been proven to be successful. It could be a year, a month, a production batch or a production week.

Define production steps:

- Processes are divided into steps and presented in diagrams.
- The diagram is based on activities or on equipment, production units or profit centres.
- Show all data related to the material flow – such as composition, value, volume, data source, ecological factors – in the diagram.
- The goal is to draw a clear map of the company's process in a diagram so as to understand how the system works.

Prepare process diagram

- Where and when does the process start?
- Where and when does it end?
- List all the steps and activities in the process
- Arrange the activities
- Discuss the consequences of actions with the people involved in your business and validate their assessments as correct.
- Review the chart with workers and business partners.

Identify materials, quantities and hazards in the process

- Identify the materials involved in each step in the manufacturing process
- Mark the materials in the process diagram
- Determine the amount of material normally involved or present in this activity; mark this amount in the diagram
- Repeat the process of determining materials and quantities for each branch of the chart.

Step 2: Creating a balance of ingredients

In a stable system, the input volume of a unit must be equal to the output.

All raw or processed materials that enter a given system must exit as a product, a waste or emissions.

Step 3: Considering solutions

The following strategies can improve material utilisation:

- Good internal management with a sense of thoughtful use and management of raw and processed materials (follow product recipes, empty containers completely, seal leaks., etc.)

- Find substitutes to replace toxic raw and processed ingredients
- Consider process changes (e.g. automatic rather than manual controls);
- Consider product changes:
    - Weight reduction: The simplest and most direct way to improve material efficiency in industry is to reduce the amount of material entering the product, also known as 'weight reduction'.
    - Recycling: recycle waste materials back into industrial production
        - Internal recycling (e.g. recycling water use, usable valuable materials within the company)
        - External recycling (e.g. scrap recycling, composting of biodegradable materials)

Consider product changes: this is also an important approach, although sometimes very subtle.

- Change material
- Use recycled materials
- Avoid using harmful substances

Substitute or modify raw and processed ingredients:

- Replace organic solvents with aqueous agents
- Replace halogenated solvents
- Replace petrochemicals with biochemical products
- Select of high purity raw materials
- Use residues as raw materials
- Use biodegradable materials
- Reduce the number of ingredients
- Ban the use of substances containing heavy metals
- Overall: use fewer hazardous materials
- Use returnable packing materials

Internal circulation includes the following methods:

- Reuse: use materials or products more than once for the same purpose
- Extended use: use materials or products for other purposes

Step 4: Evaluate the solution and implement the programme

Evaluate the potential solution in accordance with the company's programme to improve materials efficiency use, then implement it:

- Prepare an action plan
- Deploy selected solutions
- Evaluate the effectiveness of the solutions

5.4 Reducing waste

WHAT: Waste Reduction

Waste is defined as non-product outputs that have no market value or add a negative value to the market. Waste can be solid, liquid or gas. Water and emissions, although non-product outputs, are not considered waste.

In RECP waste/waste is defined as misplaced resource; waste/waste will pollute the environment. Depending on the quality, waste is classified as follows:

- Minerals: inert, insoluble, non-degradable. Mineral waste is intrinsically safe and can be disposed of without special landfill technology or long-term landfill management practices
- Non-Mineral: Waste is classified as non-mineral if it is chemically or biologically reactive. This category of waste is soluble and compostable. Elimination of it requires special disposal, landfill and/or permanent landfill disposal technologies. Garbage must be non-mineral, but can become mineral through waste treatment technology.

Waste treatment technology is divided into the following categories:

- Reuse, remanufacture, recycle
  - Reuse is the use of a component, part, or product after it has been removed from its service life. Reuse does not include manufacturing, but may include cleaning, repairing, or refurbishment upon conversion.
  - Remanufacturing is taking some component, part or product after it has been removed from its service life, and moving it into a new manufacturing process that goes beyond cleaning, repairing, or refurbishing when switching use.
  - Recycling is the recovery and reuse of materials from scrap or garbage, for the production of new products:
    - Open loop: Recycled, reused, or remanufactured materials are not returned to the processes of the reporting entity (e.g. company or factory); instead, it is returned to the market.
    - Closed loop: Recycled, reused or remanufactured materials are returned to the processes of the reporting entity. In-process recycling is the shortest possible closed loop.
- Incineration: incineration will mineralise the waste, reducing the volume of solid waste. Incineration creates other waste streams such as exhaust gases, dust, slag, heat, etc., which need to be handled separately.
- Sanitary landfill: Sanitary landfill provides a place for litter. A sanitary landfill is a controlled area of land on which waste is disposed of in a manner consistent with the standards, laws, or directives of a governing body.
- Landfill: an open dump is an uncontrolled area of land on which waste is dumped, which may be legal or illegal.
- Special cases:
  - Primary treatment is the process of preparing waste for incineration or landfill.
  - Temporary reserves for waste storage on site

WHY: Benefits from waste reduction

- Less soil pollution
- Less worry about waste
- Lower amounts of garbage to deal with

HOW: Implementing a waste reduction programme

Step 1: Drawing a garbage graph

Identify the main problem/main type of waste related to the processes of the business or the production of the industry

Collect and research all available documents and information relating to the work, plant or industry in the area

Important questions:

- What types of waste are directly related to the company's operations?
- Where is water used most?
- Do the chemicals used by the company have special instructions for how they are to be used?
- Does the company pay handling and disposal fees? How much?
- Where is the company's solid, liquid and gaseous waste disposal point?

Prepare process diagram

- Where and when does the process begin?
- Where and when does the process end?
- List all the steps and activities in the process
- Sort all operations into a sequence

Step 2: Balance the materials

- Define input
- Measure current waste recycling/reuse
- Quantify the output of the production process
- Quantify waste outside the production area
- Synchronise input and output information for each operating step
- Preliminary material balance for each operation step
- Do a material balance assessment
- Refine the material balance assessment

Step 3: Identify the source of garbage

Garbage can be generatedby contaminated raw materials, by the production process itself, by cleaning, by quality control.

Here are some examples of waste reduction:

- Resource optimisation: material optimisation
- Reuse scrap
- Improved production process management and quality control: Closer supervision and even better automated means of management can help reduce batches
- Garbage exchange: The waste from one process can become an input for another process
- Separation: Separating waste can provide better opportunities for waste reuse and recycling, saving significant money on raw material costs.

Step 4: Consider solutions

Waste can be significantly reduced through improved operations, better handling and greater care. The following waste reduction suggestions can be implemented immediately with little or no cost:

- Sorting and ordering materials: Do not overorder raw materials, especially raw materials or ingredients that are perishable and difficult to store.
- Receiving materials: Suppliers should be required to manage quality by rejecting broken, leaking or unlabelled packages. Visually observe all materials arriving at the production site. Check the weight of each bag, and check that the incoming volume is equivalent to the quantity ordered, check whether composition and quality are correct or not.
- Storing materials: Specialised containers to hold only one material require less cleaning than containers holding many types of materials.
- Transferring and handling materials and/or water: Minimise material transportation time. Check the material transmission line to avoid overflow and leakage.
- Controlling the production process: Design a control programme to check waste from each production unit. Regular maintenance of all equipment will help reduce losses in the production process. Communicate regularly to employees about the benefits of emission reductions.
- Cleaning and sanitation: Limit the amount of water used for cleaning, flushing tanks and containers. Using water indiscriminately will put pressure on the wastewater stream. Research on how to store and reuse wash water before disposal; the same applies to cleaning solutions, which can be used more than once. Tightening up on-site management processes can lead to significant waste reductions.

5.5 Efficient Use of Chemicals

WHAT: Challenges to the efficient use of chemicals

Any exposure to chemicals poses a risk to human health.

Chemical substances can cause physical effects such as explosions, or fire causing injury to people and damage to facilities.

Although chemicals pose a risk to everyone, workers are often exposed to more hazardous chemicals than others due to the nature of their day-to-day work.

Chemicals that are particularly hazardous:

The impact of cadmium (Cadmium): Cadmium is a toxic metal that can be found in the plating of some steels and steel screws, and in the coating of electric welding rods. Cadmium fumes (produced during arc welding) can be fatal even with short-term overexposure. Overexposure to cadmium can be enough to cause death, with symptoms appearing rapidly, and in some cases, days later.

The effect of mercury (found in florescent light bulbs): Mercury is very toxic and can be deadly if inhaled; skin contact is also very harmful. It may damage the kidneys, the nervous system, and the digestive and respiratory systems. Mercury can also interfere with the treatment of lung injuries. The skin is very sensitive to mercury, which can cause allergic skin reactions; it can also produce behavioural effects (results derived from animal experiments).

The effect of ammonia (as refrigerant of refrigeration systems): Ammonia can be safely used as a refrigerant as long as the system is properly designed, installed, operated and maintained. Nonetheless, ammonia is toxic and can be harmful to human health.

WHY: Benefits from the efficient use of chemicals

- Reduced costs and environmental impact
- Competitive advantage from correctly using and recycling chemicals
- Improved worker safety and health

HOW: Establish a chemical management programme

Step 1: Identify the substances

Chemical inventory: Establish a toxic chemical inventory to:

- Gain a better understanding of main toxic chemical storage locations in the company
- Identify actions to reduce risk from storage controls before incidents occur
- Optimise product inventory as an opportunity to improve the use of orders and cut costs
- Identify excess products
- Identify unknown substances that can be used before their expiration date or disposed of at the right time
- Reduce losses due to expired substances in stock
- Check packaging conditions (damage, humidity, leaking, etc.)
- Avoid accidents and explosions caused by incompatible materials placed next to each other or improperly combined

What you need to know about chemicals stored and used in the company:

- Chemical type
- Characteristic
- Storage place
- Container type
- The average number

Where is the information found?

- Purchase documents
- Warehouse control papers
- Inventory
- Manufacturer’s product information

- Sales documents
- Product labels

Minimum information to note during chemical inventory:

- Chemical name, brand/CAS number
- Where it can be stored and used
- Amount to be used
- R/GHS classification
- Location of the material safety data sheet, to which workforce is it available
- Notes on handling, storage, disposal, etc.
- Is the chemical a single substance or a compound?
- Do the chemicals evaporate during handling, mixing, or manufacturing?
- Do the chemicals generate waste during work (e.g. dust, odours from welding)?
- Are the chemicals used as modifiers (e.g. fats, solutions, dyes, paints, adhesives)?
- Are the chemicals used for a purpose outside of the manufacturing process, e.g. cleaning the workplace, machinery maintenance (cleaning agents, disinfectants, solvents, degreasers, fuels)?
- Are chemicals in the company's final product(s)?

Step 2: Identify hazardous substances by means of:

- Chemical safety data sheet
- Labels on chemical packaging
- Technical guidance of the device
- Technical standards and regulations
- Technical and scientific documents
- Records of work accidents or occupational diseases
- Interviewing workers

The importance of Material Safety Data Sheets (MSDS)

The MSDS of a chemical includes details of the risks associated with that chemical and information on how to use it safely. Chemical suppliers are required to include this information when delivering chemicals.

Labeling: The GHS (Globally Harmonized System of Classification and Labeling of Chemicals[2]) includes the following elements:

- Balance criteria for classifying substances and compounds according to health, environmental and physical hazards.
- The hazard information factors have been balanced, including labelling standards and safety data.

2 United Nations Economic Council for Europe – Globally Harmonized System of Classification and Labeling of Chemicals (UNECE–GHS), https://www.cirs-group.com/en/chemicals/un-ghs-globally-harmonized-system-of-classification-and-labeling-of-chemicals

Step 3: Design a flowchart

Prepare process flow diagrams:

- Where and when does the process begin?
- Where and when does the process end?
- List all the steps and activities in the process, some of which may appear simultaneously
- Sort all operations into a sequence
- Discuss the sequence of activities with relevant people in your company and make sure it is correct
- Review the chart with workers and business partners including:
    - Workers and supervisors
    - Providers
    - Transporters
    - Customers
    - Other stakeholders

Identify all chemicals, quantities used and related hazards that are involved in the manufacturing process:

- Identify the chemicals involved in the first step of the manufacturing process, and mark them on the chart
- Determine the quantity of chemicals often used in this activity. and mark them on the chart
- Identify hazards associated with each chemical and activity through the MSDS material safety data sheet provided by the supplier
- Be sure to identify the hazards of all chemicals involved in this activity, and mark them on the chart
- Repeat until the entire manufacturing/production process has been plotted

Step 4: Identify health, environmental, social and economic risks

- Establish a hazard assessment team: Identify which employees can help you make a simple but careful assessment of the hazards associated with the toxicity of your company's chemicals
- Review Hazard Hotspots by going back to the flowchart to locate the hazard hotspots you have identified and marked on the chart.
- Identify hazards and vulnerable groups and areas, and assess in the case of an accident.
- Identify possible accident scenarios related to the hazard hotspots you have identified
- Determine the severity of the health, environmental, social and economic impacts of a potential accident situation
- Assess the probability of an accident occurring
- Identify risk factors for each hazard hotspot, using a risk assessment matrix
- Prioritise hazardous hotspots
- Map the locations of identified hotspots. List hotspots and hazards and prioritise them by the specified risk factor:
    - Activities at the enterprise
    - Activities outside the enterprise

Step 5: Considering solutions

- Decide and apply appropriate measures to reduce and control the risks
- Carry out a hazard reassessment to check if the measures would actually reduce the severity and/or frequency of the hazard's occurrence

Appropriate solutions to mitigate or minimise risk include removal of unnecessary tasks, replacement of products, isolation, and taking technical or administrative measures.

Removal: When a task involves the use of a substance or process that is not absolutely necessary, a possible solution is to remove the substance or process .

Replacement: The replacement is to use safer products or measures:

- Safer substances
- Safer practices or processes

Isolation: Isolation includes isolating processes or substances from workers, incompatible materials, and ignition sources by keeping a distance, or shielding, or both, to prevent or reduce worker exposure and hazards associated with dangerous goods and substances.

Technical supervision: this type of oversight includes the use of equipment or processes to:

- Stop or reduce the generation of new or unwanted substances
- Stop or store substances so that they cannot get into unwanted areas, e.g. ventilation systems
- Reduce the contamination area in case of spills, spills, leaks

Administrative management is a system of labour and safety procedures that can prevent or reduce risks to health, human property and the environment.

Personal protective equipment (PPE): protective clothing and equipment for workers, supervisors and visitors, effective in protecting safety.

Training and information for workers: Workers need to know how to use and store substances safely. The law requires employers to provide information, instruction and training to workers about toxic substances and the hazards associated with toxic substances and dangerous goods they may use or come into contact with. In handling or storage locations, other people in the work area such as contractors, maintenance workers, administrative staff, and visitors should be informed, instructed and trained on possible hazards, and given necessary precautions.

Safe storage of chemicals: There are a few rules and guidelines to follow to minimise the risk of storing toxic substances.

- Division of chemical storage by theirs characteristics
- Store liquids in trays close to the floor
- Store water-distinguishable substances separately from water-indistinguishable substances. If possible, store them in two separate rooms
- Do not store chemicals at workplace
- Keep papers and preservation records
- Replace high-risk chemicals

6. Wastewater treatment

The purpose of this chapter is to provide a summary of the principles for dealing with the most pressing environmental problem of the pangasius processing industry: wastewater.

The Resource Efficient and Cleaner Production (RECP) programme supports businesses to improve the state of the environment by reducing pollution being discharged into the environment, and by improving fuel efficiency. However, in order to meet the discharge standards for wastewater, additional end-of-pipe solutions are still required in some cases, described below.

Production wastewater (from processing plants, production auxiliary systems such as refrigeration systems, and domestic wastewater from e.g. toilets, canteens) is discharged through the closed factory sewer line leading to the wastewater treatment plant. Sewer grates are installed here to separate all solid components (garbage, large residues, etc.) that might affect the treatment of wastewater. Garbage and solids are to be collected and treated periodically.

After that, the wastewater is separated from fatty components in grease separation tanks. In these tanks, light grease floats to the top and is recovered, and the wastewater then goes to the conditioning tank.

The conditioning tank, continuously aerated to avoid sedimentation and anaerobic decomposition of organic matter that can produce foul odours, stabilises the flow and pollution concentrations in the wastewater so that the rear functional tanks can operate stably.

From the conditioning tank, the wastewater is pumped into the flotation tank where a mixture of air bubbles is injected into the wastewater so that they mix with the wastewater into a fine foam that floats to the top and collects the floating oil scum and suspended sludge. Grease and sludge are separated from the wastewater by an automatic wiper device that collects the sludge in the mud tank. Coagulation chemicals are added to increase the efficiency of the grease and sludge separation, and at the same time, phosphorus removal from the whole system is improved by this step.

Next, the wastewater is passed through the anaerobic tank. In anaerobic tanks, anaerobic microorganisms will decompose organic substances in wastewater into simple inorganic substances and biogas.

After the anaerobic tank, wastewater is led through the anoxic and aeration tanks. The anoxic combined with the aerobic tank is selected for general treatment: removal of biochemical oxygen demand (BOD), nitrification, reduce NH_4+ and NO_3- to N_2, and dephosphorylation.

Using an activated sludge tank in combination with anoxic and aerobic treatment processes will take advantage of the amount of carbon when removing BOD, so there is no need to add carbon from the outside when reducing NO_3-, thus saving 50% of the oxygen when nitrifying to reduce NH_4+ by taking advantage of oxygen from the NO_3- reduction process.

In the aeration tank, aerobic microorganisms will decompose and convert organic matter into biomass, CO_2 and water. These organisms aggregate as activated flocs, which utilise dissolved oxygen from the gas distribution system. When a source of dissolved oxygen is ensured, biological oxidation of pollutants is carried out thoroughly. Wastewater will be cleaned and the microbial biomass will increase. From here, the activated sludge is circulated back to the anoxic process.

The wastewater, after leaving the activated sludge tank, overflows through the settling tank to separate solids from liquids. After settling, the sludge is circulated to the anoxic tank to maintain the concentration of microorganisms in the tank. The excess sludge is pumped to the sludge storage tank. Sludge is stored and periodically collected and treated. After settling, the wastewater is filtered and disinfected, then discharged to the receiving water source.

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