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Review Article

Industrial Pollution Prevention, Food Sector, Water and Energy Conservation Case Studies at Edfina Company for Preserved Foods, Alexandria, Egypt

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Abstract

Edfina Company for Preserved Foods, are of great importance Alexandria, Egypt, as they contribute to its development and economic diversification. However, it is necessary to pay attention to the possible environmental impacts caused by the corresponding activities. Thus, the adoption of Cleaner Production (CP) techniques can contribute to improving production processes, as well as providing. economic benefits, environmental protection and better working environment (Table 1).

Source: SEAM (1998)

The objective of CP implementation is to make companies more efficient and less polluting. The project was implemented with the contribution of the Egyptian Environmental Affairs Agency (EEAA) through the "Support for Environmental Assessment and Management" program in Edfina Company for Alexandria, Egypt.to reduce the amount of energy and water consumption (SEAM).

Keywords: Preserved Foods; CP Techniques Implemented; Water; Energy Conservation; Generated Wastes

Table 1: Benefits of Pollution Prevention at Edfina Company.

Reduce	Improve
Production costs;	overall operating efficiency;
losses of valuable raw materials;	generation of income through reuse and recycling of wastes;
on site treatment costs;	this approach can be easily replicated in sister factories to achieve similar savings;
energy and water costs;	safety of employees;
the volume of solid and liquid wastes generated;	safety of employees;
the risk of spills and accidents.	legislative compliance;
	company image.

Introduction

The following case study elaborates how cleaner production techniques can be applied in a food sector industry. The project was implemented with the contribution of the Egyptian Environmental Affairs Agency (EEAA) through the SEAM "Support for Environmental Assessment and Management" program in Edfina Company for preserved food to reduce the amount of energy and water consumption (SEAM). Edfina Company is one of the largest producers of preserved food in Alexandria, Egypt. Waste minimization through improved quality control procedures was implemented at Edfina Company for Preserved Foods (Edfina), Alexandria. A number of interventions costing LE 65,200 have yielded annual savings of LE 382,622. Quality control training and the implementation of Hazard Analysis and Critical Control Point (HACCP) system will lead to improved product quality and further savings. Although it is difficult to quantify at this stage further savings of LE 550,000 could be expected in the short term [1-5].

The Factory

Edfina is a public sector company and its factory at Montazah, Alexandria is one of the largest producer of preserved foods in Egypt. Built in 1958 on 56,000 m2 the plans, to its current level of 600 employees. Production is seasonal and is around 12,100 tons per year comprising: 4,600 tons of fruit juice and syrup; 3,900 tons of jam; 1,700 tons of canned beans and vegetables; 1,050 tons of frozen foods; 500 tons of tomato paste; and 350 tons of honey and other products.

Process Description

Processing of the 5 Main Products can be Summarized as Follows in Figure 1:

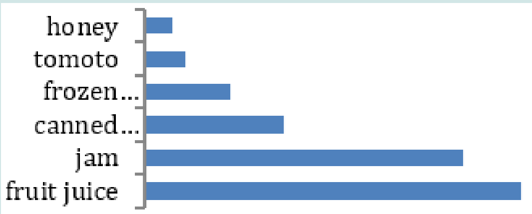

Figure 1: Edfina company for preserved foods products (ton/year).

a) Juice Drink: Fresh fruits are received, sorted, washed and squeezed. Pulp is heated, screened and mixed with ingredients. The mixture is heated, screened, homogenized, either bottled or canned then pasteurized. Product is incubated before final packaging and storage.

b) Canned Jam: Fresh fruits are sorted, washed, peeled then cut. The fruit is then mixed with sugar, steam cooked and concentrated under vacuum. Concentrate is packed in tin cans, or jam pots, sterilized and stored.

c) Frozen Vegetables: Fresh vegetables are received, weighed, sorted, trimmed, peeled and cut manually. Peeled vegetables are sorted, blanched, frozen, sieved, and packed in pouches.

d) Canned Cooked Beans: Green beans are received, weighed, sprayed with insecticide, sieved, sorted, dip and spray washed, and soaked. This is followed by steam cooking, rapid cooling and final sorting. Cooked beans are seasoned, canned and sterilized.

e) Canned Tomato Paste: Raw tomatoes are received from suppliers, weighed, sorted and washed. Clean sorted tomatoes are pressed for juice and screened. Seasoning is added and juice is concentrated under vacuum and heat treated. Paste is automatically canned, sterilized, sealed, cooled and stored. The annual production of preserved food at factory is presented in. The production levels, shown in the (Table 2), are based on full capacity.

Table 2: Annual Production of Edfina Company.

Production line	(tons)
Fruit juice	4,484
Jam	3,839
Canned vegetables	231
Canned beans	1,428
Frozen vegetables	812

Tomato paste	519
Other TOTAL	258
TOTAL	11,571

Process and Service Units

There are two canning facilities, a freezing unit, two can making plants, and a varnishing and printing facility on site. Service units include a water treatment facility, boiler station, quality control laboratories, freeze-storage and refrigerators in addition to cooling towers, garages and maintenance workshops.

Energy and Water Consumption

Table 3: Annual Electricity and Boiler Fuel Consumption at Edfina Company.

Electricity (kWh)	5.95 million
Boiler fuel oil (tons)	2,419

Table 4: Water Consumption at Edfina Company (per Annum)

Water consumption	700,000m3
Water use Process and washing Cooling Domestic use	41% 42% 17%

Table 5: Water Source and Discharges at Edfina Company.

Source of water	Discharge (m3/y)	Discharge destination
Water from municipality	520,000 Public sewer network	Public sewer network

The types of energy used in the factory are electricity, heavy oil, diesel fuel and steam as shown in Table 3. Electricity is used mainly for the machines in the industrial process, process control and lighting. Diesel is also used for vehicles, varnishing and the printing plant. Concerning the steam generation, at Edfina Company there are two boilers (12 ton/h) each. The annual water consumption and use in the factory are shown in Table 4. source of water were used as shown in Table 5 from municipality.

Wastewater Generation

Around 520,000 m3/year of effluent are discharged untreated into the public sewerage system. Effluent quality is BOD - 845 ppm; COD - 1,445 ppm; TSS - 2,225 ppm; Oil and Grease - 95 ppm; and TDS - 1,275 ppm. The factory is in the process of installing a wastewater treatment plant (Table 6).

Table 6: Wastewater Generation in Edfina Company.

Wastewater Characteristics	
BOD	845 ppm
COD	1,445 ppm
TSS	2,225 ppm
TDS	1,275 ppm
FOG	95 ppm

BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; TS: Total Solids; TSS: Total Suspended Solids;

FOG: Fats, Oil and Grease.

CP Techniques Implemented

From the above analysis we can classify the modifications achieved at the Edfina company as (Figure 2):

a) Good housekeeping: Leakages were repaired by fixing or replacing defective valves and steam traps. Water overflow and spillages were avoided.

b) Technology change: By installing a cooling tower for the bottled juice line associated with collecting sump, pumps and piping instead of using water for cooling in an open cycle. Part of the process was changed, and a new technology was used.

c) Better process control: By controlling the steam flow by installing a temperature controller on the sterilizer and using a larger tank to avoid overflow and insulating the bare steam pipes to avoid heat losses and reducing the air fuel ratio to improve boiler efficiency.

d) On-site recycling: By recycling the condensate resulting from the tomato paste process as well as recycling the cooling water in the bottled juice line.

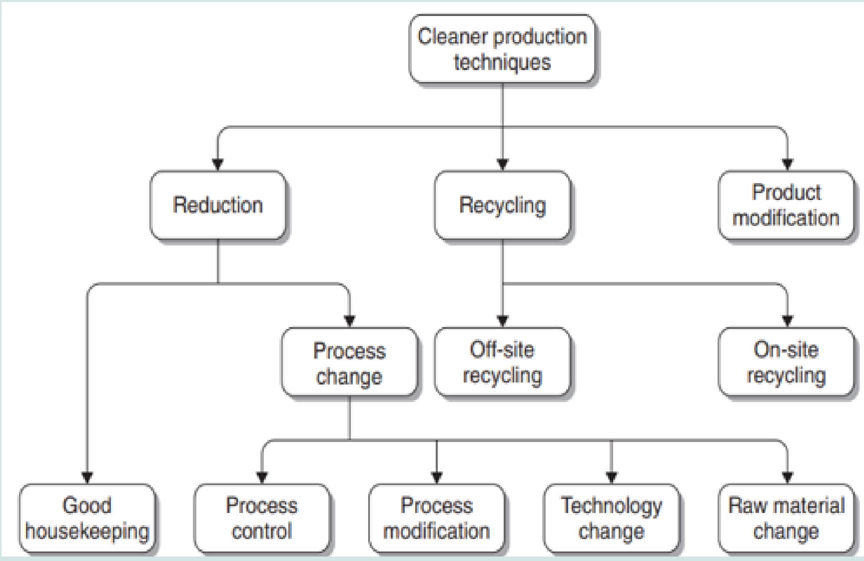

Figure 2: CP Techniques. Source: El-Haggar (2007).

CP Opportunities Assessment

The CP industrial audit for Edfina factory concluded that water and energy consumption are very high. The CP opportunities assessment for water and energy audits indicate the following opportunities (Table 7). The CP audit selected a number of cleaner production solutions taking into consideration the technical, economic and environmental aspects (Table 7). The energy audit was responsible for the fuel and steam consumption in the factory. Their major objective was to decrease energy loss and fuel consumption.

Table 7: CP Opportunities for Edfina Company.

(A) Energy issues	(B) Water issues
Heat losses due to poor insulation of steam lines.	Water leakage in some of the processes.
Leakage of steam from the processes.	High water consumption due to open cooling cycles.
Steam losses from steam traps due to poor maintenance and defective steam traps (the purpose of a steam trap is to let water that condensates in steam lines escape while stopping the flow of steam from escaping).	High water consumption in vegetable washing.
Condensate is usually discharged to the drain.	High water consumption in floor and equipment washing.
Lack of steam traps in some jacketed equipment.	Taps and hoses left running.
Steam losses in the process of can sterilization (done by direct steam injection in water).	Lack of cooling water recovery systems.
Power factors were less than 90% (the value of the utility contract without penalty).	

CP Applications

The energy audit focused on fuel and steam consumption. The factory had previously addressed electricity usage and hence only power factor measurements were recorded by SEAM. Power factors were less than the Utility contract value of 90%, which may result in contract penalties. Upgrading the correcting capacitor will allow optimisation of the power factor (Table 8). Similar measures to reduce steam and heat losses, thereby saving energy and water, were implemented by the SEAM Project at factory. Interventions to reduce water usage were only undertaken at Edfina. It should be stressed that the savings indicated are based on current production levels and would increase 2-3 times when the factory are operating at maximum capacity.

Table 8: CP Applications for Edfina Company.

(A) Energy saving measures	(B) Water savings measures
Insulation of steam pipes	Installation of water meters
Replacement/Installation of leaking steam traps	Installation of hose nozzles
Replacement of leaking steam valves	Improving the water collection system on the juice line
Installation of pressure regulators	Installation of cooling tower for the bottled juice line
Recovery of steam condensate	
Improved boiler efficiency	

Energy saving measures

Insulation of Bare Steam Pipes: The lack of insulation of the steam pipes resulted in significant heat loss. A Rockwool insulation of 80 kg/m^3 density was used to insulate 1,475 m of bare steam pipes at Edfina resulting in the savings shown in Table 9. Steam savings are estimated at 5,394 m3/y.

Table 9: Annual Savings from Insulating Steam Pipeline.

Steam saving (m3/y)	5,394
Fuel saving (ton/y)	440

Replacement of Leaking Steam valves: Leaking steam valves cause steam loss. At Edfina factory 98 leaking steam valves were identified (ranging in size from 1.27 cm to 10.1 cm). It was assumed that every defective valve leak 7.5 kg steam per hour. This resulted in the savings shown in Table 10. Replacement of the defective valves resulted in steam savings of 1,055m3/y at Edfina. Fuel savings was 86 ton/y.

Table 10: Annual Savings from Steam Valves.

Steam saving (m3/y)	1,055
Fuel saving (ton/y)	86

Replacement of Defective Steam Traps: Edfina use steam jacketed equipment in fruit and tomato pre-cooking, juice pasteurisation, jam vacuum cooking, tomato paste concentration and bean pressure cooking. Only some of the equipment was fitted with steam traps. In addition, many existing steam traps were defective resulting in wasted steam and higher output of the boiler. At 35 steam traps were installed at Edfina on 0.5-1-inch diameter pipes. Edfina steam traps were installed resulting in the savings shown in (Table 11).

Table 11: Annual Savings from Steam Traps.

Steam saving (m3/y)	1,362
Fuel saving (ton/y)	111

Installation of Temperature Controller on Sterilizers: The sterilization for the juice, jam and tomato paste production use water heated with direct steam. To avoid excessive steam losses in these production lines 4 temperature controllers with automatic pressure regulators were installed in factory on steam lines entering the sterilizers. The temperature controller-steam regulator regulated steam flow according to hot water temperatures; reducing steam pressure from 8 bar to 2 bar resulted in steam savings of 1,000kg/h per regulator. Steam savings are estimated at 3,600m3/y at Edfina. Fuel savings are 294t/y. This resulted in the savings shown in (Table 12).

Recovery of Steam Condensate: 2.75 tons of steam are required to produce one ton of tomato paste and 3.75 tons of tomato juice. After recovering the required heat (latent heat) from the steam, the steam will condense and discharge to the sewer or return to the boiler for water and energy conservation. By recycling this condensate, the savings were achieved as shown in Table 13.

Each ton of paste required 3.75 tons of tomato juice, releasing 2.75 tons of water vapor. The evaporators operate at 0.7 bar and 80°C. By recycling the condensate water savings of 3,867 t/y. Fuel savings were correspondingly 29t/y.

Table 12: P Annual Savings from Using Temperature Controller.

Steam saving (m3/y)	3,600
Fuel saving (ton/y)	294

Table 13: Annual Savings from Steam Condensate.

Steam saving (m3/y)	3,867
Fuel saving (ton/y)	29

Improving Boiler Efficiency: By reducing the air to fuel ratio to 20–30% excess air, boiler efficiencies were improved at the two factories by an average of 3% resulting in fuel savings. Fuel savings was 85 ton/year for Edfina company.

Water Savings Measures

Concerning the water saving achieved in Edfina factory, the following measures were implemented. Overall water consumption is 650-750 m3/d. Water saving measures implemented are summarized below. In addition water meters were placed in 13 locations in the factory to monitor water consumption.

Installation of Water Meters: Water meters were installed in 13 different locations to monitor water consumption. Monitoring is one of the very important tools for cleaner production to measure the consumption before and after modification to be able to calculate the amount of savings. Water savings are estimated at 9,000m3/y. This resulted in the savings shown in (Table 14).

Table 14: Water Savings– Cost/Benefits, Edfina Company.

Action	Water savings (m3/y)	Costs of works ($)	Annual savings ($)	payback (month)
Hose nozzles	9,000	860	1,580	7
Rehabilitation of the water collection system	24,000	1,480	4,210	5
Cooling tower for juice sterilizer	86,400	14,880	15,160	12
TOTAL	119,400	17,220	20,950	10

Installation of Hose Nozzles: A huge amount of water was needed to clean the tanks and wash the floors in the tomato paste section. On/off spray nozzles were fitted to control the water consumption. A water saving of 9,000m3/y was achieved in Table 14.

Improving the Water Collection System on the Juice Line: The cooling water from the juice line was collected in a tank to be recycled. This tank was smaller than the flow of water resulting in overflow. A larger tank with a new water pump was installed resulting in annual savings of 24,000m3/y.

Installation of cooling tower for the bottled juice line: Juice bottles were sterilized at 90°C then cooled by water in an open cycle. A cooling tower was installed to recover and recycle the cooling water in a closed cycle. A water saving of 86,400m3/y was achieved (Table 14).

Cost Savings

Cost savings have been estimated on current production levels and would increase 2-3 times when factory was at full production. Annual savings indicated are based on fuel savings, which account for 85% of the cost of steam. Cost benefits for the various interventions are summarized below (Tables 14 & 15). The cleaner production solutions proved to be very effective from the technical and environmental points of view. The cost/benefit analysis is summarized in Tables 14 & 15. The payback period calculated in all case studies is called the “projected payback period” because it is based on investments and savings only without taking into consideration the running cost. This is due to the fact that the factory is operating with all necessary staff and infrastructure. The annual savings for energy are based on fuel savings.

Table 15: Energy Savings – Cost/Benefits, Edfina Company.

Action	Heavy oil savings (ton/y)	Costs of installation ($)	Annual savings ($)	Projected payback (month)
Insulation of steam pipes	440	21,792	14,049 19	19
Replacement/Installation of leaking steam traps	111	2,452	3,544	9
Replacement of leaking steam valves	86	8,244	2,746	36
Installation of pressure regulators	294	7,642	9,387	10
Recovery of steam condensate	29	5,821	1,589	44
Improved boiler efficiency	85	0	2,714	0
TOTAL	1,045	45,952	34,029	17

Benefits

The benefits of the CP solutions at Edfina company were:

a) Steam savings of 15,278 m3/y was attained.

b) Fuel oil consumption was reduced by 40%.

c) Water consumption was reduced by 17%.

d) Wastewater volume and hence the load on the wastewater treatment facility were reduced.

e) Energy savings implemented with an overall average payback period of 12 months.

f) Water savings implemented with an average payback period of 10 months.

Conclusion

CP is proven to be an efficient technique in improving material consumption, reducing energy utilization, and decreasing emission levels of pollutants. CP also encourages positive, defensive action and encourages a holistic view of resources, economy, production, and the environment. Case studies showed that CP application changed the quality and quantity of raw materials, consumed energy, production, generated wastes, and working environment.

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