

RECYCLING COSTS: A RESEARCH IN THE WASTE PAPER INDUSTRY

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ABSTRACT: *Since the day it is invented till today, paper is a part of human life in various ways and it is gaining even more popularity as years go by. As the consumption of paper has been increasing, the problem of sourcing raw material is emerging. As a result, natural resources are being exploited. Recycling of paper has become vital since the demand for paper has increased and natural resources are being exploited. In this study, paper industry is analyzed in regard to recycling and the process of producing paper in a recycling factory and proportional weighted costs of recycling are presented. Thus it is intended to assist managers of waste paper recycling factories to make strategic plans and also those who will start up new factories. Study concludes that weight of waste paper as a raw material within the costs of factory is 43%.*

KEY WORDS: Waste Paper, Recycling, Costs of Waste Paper

INTRODUCTION

Paper has an indisputable place in establishment of civilizations, saving information and passing it to next generations. Paper in today's world is used in everyday life for countless purposes so its consumption has been increasing. In order to solve the problem of sourcing raw material for paper production, it is better to develop technologies for sustainable recycling rather than sustainable forestry. Thus, separating all the components of waste paper except for fibers using the most economical and environmentally friendly methods and recycling are crucially important (Karademir et al. 2012).

It is previously thought that consumption of paper would decrease as a result of developing technology but in contrast developed technology has caused an increase in paper consumption. As the demand for paper has increased, paper producers are now forced to use waste paper as the raw material. Because there is a decrease in the quantity of natural resources such as wood, hay and cotton (which are used as raw material for production of cellulose, and cellulose is the raw material of paper), reforestation takes a long time and environmental pollution and cost of energy has increased (Yakut, 2012).

Waste management strategies are used to prevent fast depletion of natural resources, to avoid wastes being a threat to environment and human health and to transform wastes into an economic input and value. These strategies provide a basis for "sustainable development" approach which is adopted as primary political goal all over the world. When it is taken into consideration that natural resources and their capacity to renew themselves are limited, in the frame of sustainable development approach, social, environmental and economic effects of recycling under waste management come into prominence (National Recycling Strategy Document and Action Plan, 2014-2020).

PAPER PRODUCTION

The history of paper goes back to 3rd century BC. It has started in the 17th century to produce paper in today's form. Paper consumption has increased after industrialization and cultural activities became more intense and paper started to be used for packing industry in addition to press. When paper consumption increases, paper waste too increases due to domestic and industrial waste. Paper waste as a proportion to solid waste has increased therefore there are studies to develop technologies that produce less waste and encourage people to prefer these technologies (Binici et al. 2013).

In the first years of invention, paper was produced by hand, in low quantities as a very precious material. It was used for interstate letters, edicts and valuable documents. After 1850, instead of plants, cellulose started to be used in the production of paper. Paper production used to be an environmentally friendly process with plants as raw material. But with the advent of industrial revolution, overpopulation and consumption culture, it required serial production and needed more raw material thus deforestation started. Inevitably, forest reproduction remained weaker than destruction and forests could not meet the demand therefore to focus on paper recycling became a must (Karademir et al. 2012).

Waste Paper

Sources which are known as secondary fibers are also important in paper production in addition to wood, cotton, milk, jute, hay, cane and cannabis. Even though paper that is produced from a main raw material has superior qualities; because these sources are limited especially in our country, forestation takes a long time, natural resources need to be preserved, and energy costs are increasing; waste paper or secondary fiber becomes attractive.

Recycling is to use waste paper products in the production of paper as raw material. Therefore, environmental pollution and deforestation can be prevented. To produce paper, waste paper can be mixed with other raw material or with the new technology; solely waste paper can be used to produce new paper. Secondary fibers which are extracted from waste paper are now vital due to the increasing demand, limited forest resources and environmental pressures. Modern paper industry procures raw material largely from waste paper (İmamoğlu et al. 2005).

Recycling and Waste Management

Recycling is to utilize used products in production of new products. Material is regained without saving the original condition of used product. With recycling, used products gain economic value again (Şengül, 2010). The interest for collecting waste paper and recycling them to be used in paper production has been increasing globally. Negative change in ecologic balance in the last years due to deforestation in order to produce paper has a major effect in this increased interest for recycling. Additionally, greater consciousness level about environment and newly discovered scientific findings which suggests that cellulose can be used many times to produce paper resulted in this higher level of interest in recycling (Şahin, 2013). Recycling is a method which is applied to wastes that cannot be used again or whose formation cannot be prevented. In the waste avoidance and management statute and policy, hierarchy of wastes is expressed as follows (National Recycling Strategy Document and Action Plan, 2014-2020):

- Prevention
- Re-usage
- Recycling
- Recovery
- Disposal (Stocking / Burning)

Recycling in Developed Countries

In developed countries, excluding 35-45% of wastes, all remaining part is recycled back to economy. For example, the role of recycling becomes more prominent when increase in the need for raw material in EU which is parallel to our country, and EU's dependencies on the import of raw material are taken into consideration. European economy is mostly dependent on resource consumption. And 2020 predictions suggest that resource consumptions will continue to rise in EU. Main components of resource consumption in EU are economic growth, technologic developments and changing consumption and production habits. Nearly one in third of resources that are used in EU become waste and emission. Resource consumption is increasing in the other parts of the world as well. This is caused by an increase in product and service consumption. High resource consumption puts a pressure on environment all over the world. Among these pressures; running out of non-renewable resources, intense usage of renewable resources, high emission to water, air and earth due to transportation and mining activities, and high waste production which is affecting ecosystems negatively (National Recycling Strategy Document and Action Plan, 2014-2020).

To use waste paper as the raw material in the production of paper goes way back to old centuries but especially in the last years its volume and percentage has increased tremendously. The reasons lying behind this are as follows (İmamoğlu et al. 2005):

- Forest resources are increasingly insufficient in supplying the demand for raw material
- The burden of inert waste in cities which is really hard to destroy has been increasing
- Waste paper technologies have developed
- The consciousness among consumers have increased
- New legal obligations about using recycled paper usage
- Wide scale recycling projects are now economically feasible
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World paper production and consumption: According to 2009 data, paper production in the world is nearly 370,7 million tons. According to United Nations Food and Agriculture Organization statistics, paper production is 41,7% in Asia, 27,4% in Europe and 22,8% in North America. When we look at the percentage of countries in paper production, China is the biggest paper producer in the world with 24%. USA is the second with 21,6 million tons. The followers are Japan with 16,3 million tons, Germany with 10,9 million tons, Canada with 12,8 million tons, Sweden with 10,9 million tons, Finland with 10,6 million tons, and South Korea with 10,5 million tons.

Yurtman and Aydın presented Table 1 about recovery and usage rates in some of the Europe's countries.

Table 1. Recovery and Usage Rates of waste paper in European countries

COUNTRY	RECOVERY RATE %	USAGE RATE %
Germany	70,7	60,8
Netherlands	64,7	60,6
Austria	62	40,8
Sweden	58,2	17,8
Denmark	49,1	113,9
France	43,7	54,4
Belgium	43,6	34
Spain	43,4	80,9
Italy	33,3	49,9
Greece	31,9	99,4
Turkey	34,5	56

Source: Yurtman ve Aydın, 2001

In Turkey, waste management and recycling industry has become a nearly 5 billion euro market with the contributions from private sector and local municipalities. Recycling rate was about 35% in 2010 and has risen to 40% in 2012 and after. Recycled wastes are 43% paper, 27% plastic, 12% glass, 8% textile, 4% metal. Recycle rate of all wastes in Turkey is 7%, recycle rate of packing material is 20% which is the highest (Yetim, 2014).

Recycling Paper in Turkey and Europe

There are 46 firms operating in Turkey in paper industry. Most of the firms in the industry are middle sized firms. Paper production in Turkey was nearly 5,4 million tons in Turkey in 2009. Yearly paper production in Turkey is shown in Table 2 (Sakarya and Canlı, 2011).

Table 2. Turkey paper and paper products production

	2005	2006	2007	2008	2009
TOTAL	5.090,22	4.782,53	5.294,99	4.934,66	5.427,42

Source: Turkey Statistical Institute, <http://www.tuik.gov.tr>

Western countries develop packing rules and standards to reduce wastes and encourage recycling paper. First regulation in this subject “Green Point” took effect in 1 January 1993 under “German Packing Regulation”. Starting from this date, it is required to collect and process all packages in Germany. Green Point is a sign which shows that the product is ecologically okay. Green point on the package of product tells to the consumer that this package can be reused or recycled. Any exporter that sells packaged products to Germany has to guarantee that the package of the product can be sent back. If they cannot provide that, they have to have a deal with firms that collect packages and get a Green Point licensed.

This system that is pioneered by Germany came to a point that, following the example of Belgium, France and Benelux countries, all European countries adopt. For this reason, all the concerned bodies of Europe came together and accepted the “Package and Package Wastes Directive (94/62/EEC)” in December 1994 for the purpose of common usage for all countries. This directive covers all EU member states, their governments and firms. The directive in

question came into force in Turkey in 2007. According to this Turkey's recovery percentage rate targets for waste package paper are shown in Table 3;

Table 3. Turkey's recovery percentage rate targets for waste package paper

Years	Targeted Rate (%)
2007	35
2008	35
2009	36
2010	37
2011	38
2012	40
2013	42
2014	44
2015	48
2016	52
2017	54
2018	56
2019	58
2020	60

Source: Turkey Statistical Institute

Turkey, when compared to world, is 16th at consumption and 25th at production of paper. This situation clearly shows that Turkey is a paper importing country. Turkey's import in the industry is more than twice of its export. Therefore, it can be seen from numbers that Turkey has a growth potential in paper industry (Sakarya and Canlı, 2011).

Importance and Benefits of Recycling Paper Waste

In his article about the importance of recovery of waste paper, Eroğlu states that the importance of recovery of waste paper is explained from the perceptive of environment, forestry, energy saving, raw material resources and chemical material saving. Additionally, he said that waste paper collection rate is about 30% and because waste paper is not dissolved in its source, it will create problems about quality and environment (1993).

In the hierarchy of waste management, the primary priority is to prevent waste in the time of production and to reduce the quantity and danger level waste. To reuse, recycle and recover by means of producing energy are at the secondary priority level. If wastes are not possible to be recycled, to burn the waste without damaging the environment or to be stocked safely is the last level priority.

It is not possible to completely satisfy the need for raw material solely by recycling. But recycling plays an important role in green economy when the developing recycling market and its economic and environmental effects are taken into account. The basic findings about the place of recycling in the green economy and economic benefits that EU got from recycling are as follows (National Recycling Strategy Document and Action Plan, 2014-2020):

- The earning from recycling have been increasing
- Developing Asia economy and EU directives have been increasing recycling in Europe
- Recycling creates more employment compared to burning and stocking

- Recycling can reduce greatly the need for resources that economy requires so the pressure on resources will be weaker

In many parts of the world, many policies, projects, technologies, programs and strategies for recycling are developed and implemented. Lastly, the importance of recycling was emphasized in Rio+20, in the document of “The Future that We Desire”. It is supported with Sustainable Waste Management 3R applications (Reduce, Reuse, Recycle) (National Recycling Strategy Document and Action Plan, 2014-2020).

Karıncaoğlu explains the benefits of waste paper recycling as follows:

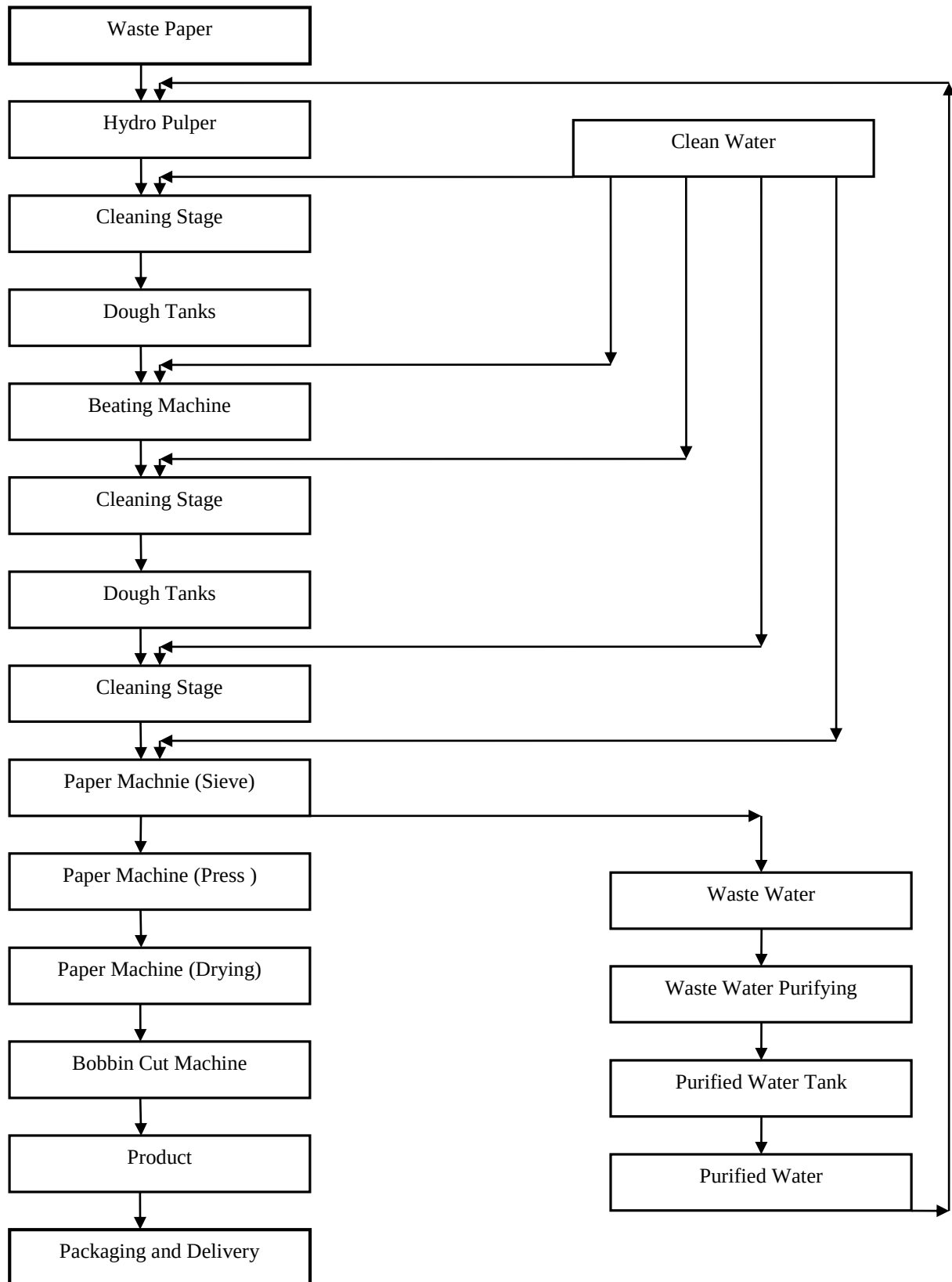
- One tree is saved every time 54 kg newspaper is recycled (Government of Canada, Digital collections).
- Each tone of recycled paper saves 17 trees (Purdue Research Foundation and US Environmental Protection Agency).
- Photocopy papers, kitchen rolls and tissues, corrugated cardboards, newspapers can be made from recycled paper (Environmental Health and Safety Online).
- Every saved tree produces the amount of oxygen that 3 people consume (North Carolina Office of Waste Reduction and Recycling).
- Recycled paper consumes 64% less energy compared to producing paper from cellulose (Energy Educators of Ontario).
- When producing 1 tone of recycled paper; 2,5 tons of petroleum and 26 tons of water is saved (Waste Reduction is a Smart Business Decision, Onondaga Resource Recovery Agency).

THE PRODUCTION PROCESS OF WASTE PAPER

Operation steps in recycling of paper products in different qualities can vary according to the means of the facility and desired paper class. Process variables that are used in recycling are studied under 5 groups, even though some discrepancies may occur (Şahin, 2011):

- Pulper
- Sieving and cleaning
- Dispersion
- Ink removal (for some special paper products)
- Whitening (for some special paper products)

The flow of how paper is produced from waste paper is shown in Table 4. So the processes that waste paper goes through are explained in detail.

Table 4. **The Flow of How Paper Is Produced From Waste Paper**

Recycling of Waste Paper

Case study was applied to a waste paper production facility. The firm has 120.000 m² outdoor and 5.000 m² indoor areas. They have one paper machine (PM) that can provide employment for 180 people on average. The paper machine is a VOITH product which is one of the leading firms in the world and made in Germany. Production width is net 320 cm, 40-140 gr/ m² and 600-800 m/min production capacity is 100.000 tons per year.

After size of the production facility, sufficiency level of infrastructure, specifications of paper machine, renewal investments made to the paper machine are taken into account, paper machine works 365 days a year (including public holidays), 3 shifts per day. 80.000 tons of Fluting bobbin paper and 30000 tons of Testliner bobbin paper will be produced, by processing 125.000 tons of waste paper. On average 10% (15.000 tons) waste paper will be returned to production line as waste product due to outage and manufacturing defects. The actual production capacity is 85.694.882 Kg of Fluting, 19.305.851 Kg of Testliner, 105.000.733 Kg in total according to 2013 data.

The process of activities and the activities in the process in the paper recycling facility and waste paper production process are presented in Table 5.

Table 5. **Waste Paper Production Process**

1. RAW MATERIAL SECTION
WASTE PAPER STOCKING
(Conservation and protection of purchased raw material)
WASTE SORTING UNIT
(Sorting of mixed raw material according to their types such as plastic, glass, iron etc.)
2. PAPIER-MÂCHÉ PREPARATION SECTION
RAW MATERIAL FEEDING UNIT
(This is the first step where waste paper is put on production line)
SPREAD THE PAPIER-MÂCHÉ (PULPER) UNIT
(To turn waste paper into papier-mâché in pulper)
ROUGH SIEVING SHELLING UNIT
(To remove papier-mâché from sand, metal and plastic)
FINE SIEVING SHELLING UNIT
(To remove papier-mâché (that had gone through rough sieving and shelling) from fine)
REJECT EVACUATION UNIT
(Evacuating foreign particles that are cleaned out from the sieving system)
FINE SAND SEPARATING UNIT
(To remove sand, soil etc. which are found in papier-mâché)
DENSITY UNIT
(To increase the rate of papier-mâché's dry matter from 1-1,5% to 9-10%)
CHEMICAL AND MILLING UNIT
(To add paper chemicals to papier-mâché whose density is high and re-milling)
3. PAPER MACHINE SECTION
BUTE UNIT OF MACHINE
(Filling of production ready papier-mâché to the bute (stocking) of machine)
HEAD BOX UNIT
(To turn papier-mâché to lamina form and transfer to sieve)
SIEVE UNIT FOR PURIFICATION FROM WATER

(To increase the rate of paper lamina's dry matter from 1-1,5% to 16-20% with the use of
PRESS UNIT
(To increase the rate of paper lamina's dry matter from 16% to 48-51% with the use of press and vacuums)
DRYING UNIT
(To dry lamina in drying cylinders up to 7,5% humidity)
QCS QUALITY CONTROL SYSTEM
(To measure the produced paper's values such as gram, humidity, quality etc. for different
STUFF WRAPPER
(To wrap the paper in production line into the buffer)
4. BOBBIN CUT SECTION
MANUFACTURED PAPER CUTTING DIMENTIONING UNIT
(To cut and dimension all buffers and turn them into the bobbins according to demand of clients)
MANUFACTURED PAPER PACKING UNIT
(To store cut bobbins to the product warehouse after weighing and packing them)

The income of the facility comes from the sales of Fluting and Testliner bobbin papers which are manufactured from waste paper. Total expected sale revenue for a year is shown in Table 6.

Table 6. **Yearly Firm Revenue**

Product Name	Production Quantity (Tone/Year)	Unit Price (kg/TRY)	Total (TRY)
Fluting Paper	85.694.882	1,00	85.694.882
Testliner Paper	19.305.851	1,15	22.201.729
Total Firm Revenue	107.896.611		105.000.733

Raw material, labour and general production costs in firm's production process are shown in Table 7.

Table 7. **Yearly Firm Costs**

COSTS	ACCOUNT NAME	AMOUNT (TRY)
710	DIRECT FIRST MATERIAL COSTS	46.719.200,64
710 00	FIRST MATERIALS	46.719.200,64
710 00 10	WASTES	39.703.883,64
710 00 20	CHEMICALS	7.015.317,00
720	DIRECT LABOUR COSTS	1.457.025,84
730	GENERAL PRODUCTION COSTS	42.580.264,68
730 00	INDIRECT MATERIAL COSTS	1.320.118,20
730 01	LABOUR SALARY AND COSTS	2.482.636,96
730 02	OFFICER SALARY AND COSTS	29.752,96
730 03	BENEFITS AND SERVICES PROVIDED FROM OUTSIDE (Energy: 15.775.940,32 TRY) Energy costs make nearly 85% of costs of this expense item	18.501.958,40

730 04	VARIOUS COSTS	16.705.798,16
730 05	AMORTIZATION COSTS	3.540.000,00
760	MARKETING, SALES AND DISTRIBUTION COSTS	15.278,24
770	GENERAL ADMINISTRATION COSTS	1.424.275,92
780	FINANCING COSTS	315.965,25
TOTAL		92.512.010,57

Nearly 43% of costs are composed of waste paper as raw material in the waste paper recycling facility. Energy costs make 16% of costs. Therefore energy costs have a high ratio within production costs. General production costs make almost half of total costs. The firm does not have the ability to decrease Direct First Material Costs and Direct Labour Costs. But in firm, where general production costs are as high as 50%, these costs should be subject to review one by one and kept under control.

CONCLUSION

Paper production, which was expected to fall with the advancement of technology, is now a part of everyday life for various purposes and its usage has been still increasing. In this study, production costs in paper recycling facilities and their weights within the total costs are evaluated and the points that recycling facilities should pay attention to are underlined. Raw material makes 40-45% of the costs in recycling facilities. When firms acquire raw material, they should operate with the optimum inventory level. Firms should watch out waste paper prices and waste paper market. They should watch sudden increases and decreases in prices and look out for the balance between supply and demand. In case of overstocking of inventory, the decreasing prices will create negative consequences. However, operating with minimum level of inventory will create disruptions in production when there are delivery problems about raw material. In recycling facilities where the ratio of energy among all costs is already high, if the machines cannot operate due to lack of supply of raw material, energy cost will increase even more. For this reason, firms should choose the raw material source well and should audit if necessary in order to minimize production costs. The firm will benefit from decreased general production costs.

According to the result of the study, in recycling facilities, raw material costs make 43% of total costs. Additionally, chemicals that are used to sort wastes make 8% of total costs which is a high ratio. If waste paper is better sorted out in its source, the amount of chemicals to be used will decrease and 16% electric cost will also decrease, thus it is anticipated that production costs will decrease.

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