



**Strategies and Mechanisms
For Promoting
Cleaner Production
Investments
In Developing Countries**



**Profiting From
Cleaner Production**

— Exercises Handout —



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The United Nations Environment Programme
Division of Technology, Industry and Economics
Production and Consumption Branch

Presents a Training Series

**Strategies and Mechanisms for Promoting
Cleaner Production in Developing Countries**

Profiting From Cleaner Production

Exercises Handout

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Small Group Exercise

“Classifying Environmental Management Options”

Objective

The “Environmental Management Hierarchy” ranks environmental management options from more desirable to less desirable, with the most desirable being cleaner production which prevents or reduces environmental wastes and emissions in the first place. This exercise will help you to differentiate among the four major categories:

- Cleaner Production
- Off-site Recycling/Reuse
- Pollution Control/Treatment
- Waste Disposal

Through this exercise, you also will learn about environmental management options actually implemented by two companies.

Approach

This exercise will be conducted in small groups to allow for discussion of the answers to the questions.

Individually read the short descriptions of the two real facilities used as case studies. Each company has come up with a list of proposed environmental management options. As a group discussion, assign each of the options to the appropriate category or categories of the Environmental Management Hierarchy. Be sure to compare your ideas with the members of your group and see if you agree on the answers. You will have approximately 10 minutes to do the two cases.

The instructor will lead a discussion of the answers that the groups have reached and the reasoning for the answers.

Flowpipe and Fitting, Inc. (FPF)

FPF (a fictitious name for a real company) makes iron pipe and fittings. The final products are used for water supply and sewage and for municipal castings such as manhole covers, grates, and lampposts. The raw material is scrap metal, which the company melts in equipment called smelters and then pours into pipe casting machines (for making pipes) or into sand casting molds (for making fittings). The smelters produce air emissions (e.g., carbon dioxide, sulphur dioxide, nitrogen oxide, and smoke/soot) and the casting process produces significant amounts of solid waste (e.g., metals other than iron found in the input scrap, used sand and bonding materials). In addition, electrical energy use at the facility is inefficient.

FPF thought of the following environmental management options for the facility:

1. Modify the smelting operating parameters to improve the efficiency of the process, thus reducing smoke generation
2. Place an airlock trap above the smelter door to prevent smoke from escaping
3. Inspect the quality of scrap metal used as raw material and separate out low quality metals and trash, thus improving product quality, reducing rejects, and reducing smoke generation
4. Wash and re-use the sand that is used as part of the casting process
5. Send solid scrap to a landfill
6. Train employees not to pour excess metal in the casting molds, thus reducing fuel use and scrap formation
7. Install equipment to reduce electricity losses

Question 1: Match the option numbers above to the Environmental Management Hierarchy categories below. You may choose to put an option number into more than one of the four major categories. For any option you decide to consider Cleaner Production, place it into one or more of the sub-categories listed.

Environmental Management Hierarchy Categories	Option #
Cleaner Production , including the following:	
• Good housekeeping	
• Input substitution	
• Better process control	
• Equipment modification	
• Technology change	
• Product modification	
• Production of a useful by-product	
• On-site recycling/reuse	
Off-site Recycling/Reuse	
Pollution Control/Treatment	
Waste Disposal	

The PLS Company

The PLS Company (a fictitious name for a real company) prints rolls of thin plastic film with packaging labels and then glues the plastic film to a thin layer of metal foil. The final product is sold to food processing firms for making food packaging. The production process produces a number of wastes, including solid scrap from start-up runs and full production runs, waste liquid ink, and solvent air emissions from printing ink and glues. PLS had the following ideas for managing the wastes:

1. Chop up the scrap and sell it to another company for use as a stuffing material for bed mattresses
2. Install an incinerator to burn the solid scrap
3. Install a quality control camera to catch printing errors earlier, thus reducing scrap generation
4. Reuse waste ink by mixing it into the black ink
5. Send the solid scrap to a landfill
6. Re-use scrap film in printing start-up runs
7. Change the employee compensation system to reward scrap reduction at each production unit
8. Purchase a new distillation unit to recycle the waste solvents
9. Use water-based glue instead of solvent-based glue, thus reducing solvent air emissions

Question 2: Match the option numbers above to the Environmental Management Hierarchy categories below. You may choose to put an option number into more than one of the four major categories. For any option you decide to consider Cleaner Production, place it into one or more of the sub-categories listed.

Environmental Management Hierarchy Categories	Option #
Cleaner Production , including the following:	
• Good housekeeping	
• Input substitution	
• Better process control	
• Equipment modification	
• Technology change	
• Product modification	
• Production of a useful by-product	
• On-site recycling/reuse	
Off-site Recycling/Reuse	
Pollution Control/Treatment	
Waste Disposal	



Small Group Exercise

“Cost Identification at the PLS Company”

Introduction

The generation of pollution or waste by business operations can be quite costly. This is true for both large and small firms, and applies to diverse business sectors, including service and resource extraction sectors as well as manufacturing sectors. The objective of this exercise is to familiarise you with the many different types of operating costs at a manufacturing facility, particularly costs related to waste generation, and have you think about how those costs might be reduced by Cleaner Production. We will use a case study from a real manufacturing firm in a developing country as an example.

Instructions

On the following pages you will find a written description of manufacturing operations at the PLS Company, as well as materials flow maps illustrating the main manufacturing steps and the waste management operations.

Take about 10 minutes to read the descriptive materials and review the two maps. Working in your small groups, answer the two questions below, both of which focus on the printing step of the manufacturing process. Then discuss your answers with the others in your small groups. The instructor will then lead a discussion with all participants together.

Question 2 (15 minutes)

The largest waste stream at the PLS Company is solid scrap, and the largest amount of solid scrap is generated by the printing step. In order to address this significant source of waste, the PLS Company has proposed to purchase a quality control (QC) camera system. This automated camera system would be used on the print line to detect print errors earlier than was possible without the camera. The result would be a significant reduction in the amount of solid scrap generated by the printing step.

(You can record your answers in the same table used to record your answers to Question 1.)

(a) If adopted, how will the QC camera impact the costs associated with the printing step or with the management of solid scrap waste from the printing step, i.e., the costs you listed in Question 1? Which costs might increase? Which might decrease? Which might stay the same? In answering this question, assume that the total amount of product coming out of the printing step (i.e., printed film) does not change.

(b) Can you think of any new costs that might be relevant for the QC camera?

(c) Of the costs that would change upon adoption of the proposed QC camera system, which might be the most significant for project profitability?



Handout

Case Study: "PLS Company Description"

NOTE: "PLS" is a fictitious name for the company on which this description and exercise are based. The facility description and data have been modified in order to protect the identity of the company and to make the case study more suitable for classroom learning.

Company Background

The PLS Company is a medium-sized firm that produces rolls of printed, laminated film. The film is sold to food processing companies, who use it to manufacture food packages such as flexible pouches for fruit juices. The acronym PLS reflects the three main manufacturing steps at the facility: Printing, Laminating, and Slitting. The attached figure, entitled "Manufacturing Steps at the PLS Company," illustrates the flow of materials through these manufacturing steps.

Step One: The Printing Process

The first major manufacturing step is the printing process, during which PLS prints multiple copies of the customer's packaging design onto a long length of plastic film. The film is purchased in the form of a roll about 800 mm wide. For a typical print job, three identical package designs can be printed across the width of the film.

The printing line has a series of large cylindrical stainless steel rollers that have been etched with the image to be printed. Each roller is coated with different colour ink so that the length of plastic film running through the rollers can be printed in multiple colours. The plastic film is fed into the printing press and a trial run is done to test the initial print quality. Once the printing process is optimised, the full printing run is done and the printed plastic film is rolled up again for the next manufacturing step. Jobs that require the printing of many colours may require running the film through the printing press several times.

The inks are based on solvents which are chemicals that are used to dissolve or carry other materials, such as paint or ink pigments, or adhesive materials. Examples of solvents are methyl ethyl ketone (MEK) and toluene. At PLS, the solvent-based ink mixtures are applied to the film, and then the solvents evaporate quickly as the inks dry, creating chemical vapours inside the plant. PLS wants to switch to water-based inks but, unfortunately, the inks they have tested so far have caused equipment rust problems.

In addition to the evaporated solvents waste stream, another waste stream generated by the printing operations is liquid waste ink leftover from the print job. This waste ink is currently sent to a landfill.

The largest volume waste stream generated during printing is solid scrap plastic film, including both the film used in the set-up run for each job and scrap generated when there is a error during the full printing run itself. Examples of printing errors include smearing of the ink, incorrect colour, and mismatching of the patterns of layers of colour. PLS handles this printed scrap material on-site, as described later.

Step Two: The Lamination Process

Lamination is the process of layering two (or more) different types of films on top of each other to achieve desired properties in the final product. At PLS, plastic film is laminated with a thin film of aluminium metal. The aluminium film is sandwiched between two layers of plastic film – one printed layer of plastic from the print step and one unprinted layer of plastic from inventory. The aluminium in the three-layer laminated film helps keep gases (such as air) out of the food contained in the final package.

The rolls of film (plastic and aluminium) are placed next to each other at one end of the laminating line. Then the films are fed through the line, glued and pressed together, and rewound into rolls. This newly laminated film that is ready for the final manufacturing step. Before running a full job, a set-up run is done to test the initial lamination quality. Once the lamination process is optimised, the full run is done. One type of waste generated during the lamination step is solvent emissions from the solvent-based adhesive used to laminate the plastic and metal layers together.

Solid scrap is produced both during set-up runs and full production runs of the lamination line, similarly to the printing line. Examples of lamination errors that cause film to be scrapped include wrinkling of one of the film layers, tunnelling (long air pockets) between layers, and delamination of one of the layers when the adhesive does not set properly.

Step Three: The Slitting Process

The final major manufacturing step is slitting the laminated and printed film. Basically, this step slits the full width film lengthwise to separate the three identical package designs printed across the width of the film. The three narrower strips of film are then re-rolled. In other words, one roll of full width laminated film becomes 3 rolls of narrower film during the slitting process. The narrow rolls of final product are shipped to PLS' customers, who use the material to make packages for shipping their food products, via bagmaking machines that fold and seal the film together in various patterns. Solid scrap is produced during slitting because of errors such as off-track slitting and lateral tears.

Solid Scrap Waste Management

PLS has a strategic solid waste management challenge. Solid scrap is the largest waste stream at the facility and PLS wants to find a way to reuse or recycle this material. The company tested the scrap as a mattress filler but the resulting mattresses were too noisy! Selling the materials for use in manufacturing streamer decorations was another option considered, but this would supply only seasonal demand for the waste stream.

Since a feasible recycling option has not yet been identified, PLS must dispose of the solid scrap. In the past, PLS landfilled the material, but landfill scavengers would use the scrap to make and sell food pouches still showing the clients' names. One client sued PLS to stop the landfilling of scrap with the client's name still visible on it. Therefore, PLS began shredding the scrap film into small pieces before landfill disposal. However, PLS felt that shredding was not a long-term solution as there were still client names visible on the shredded pieces of scrap. Therefore, PLS finally started incinerating the scrap film (instead of shredding it) to prevent misuse of the material. The attached figure, entitled "Solid Scrap Waste Management the PLS Company," illustrates the waste management steps at PLS and the flow of materials through those steps.

The on-site incinerator used by PLS is a large old brick burner. Smoke from the incinerator runs through a water scrubber, using water from a deep well on-site. The scrubber mixes the streams of smoke and water, allowing the water to absorb much of the smoke, which reduces air pollution from the incinerator. However, the resulting stream of dirty water from the scrubber has high levels of

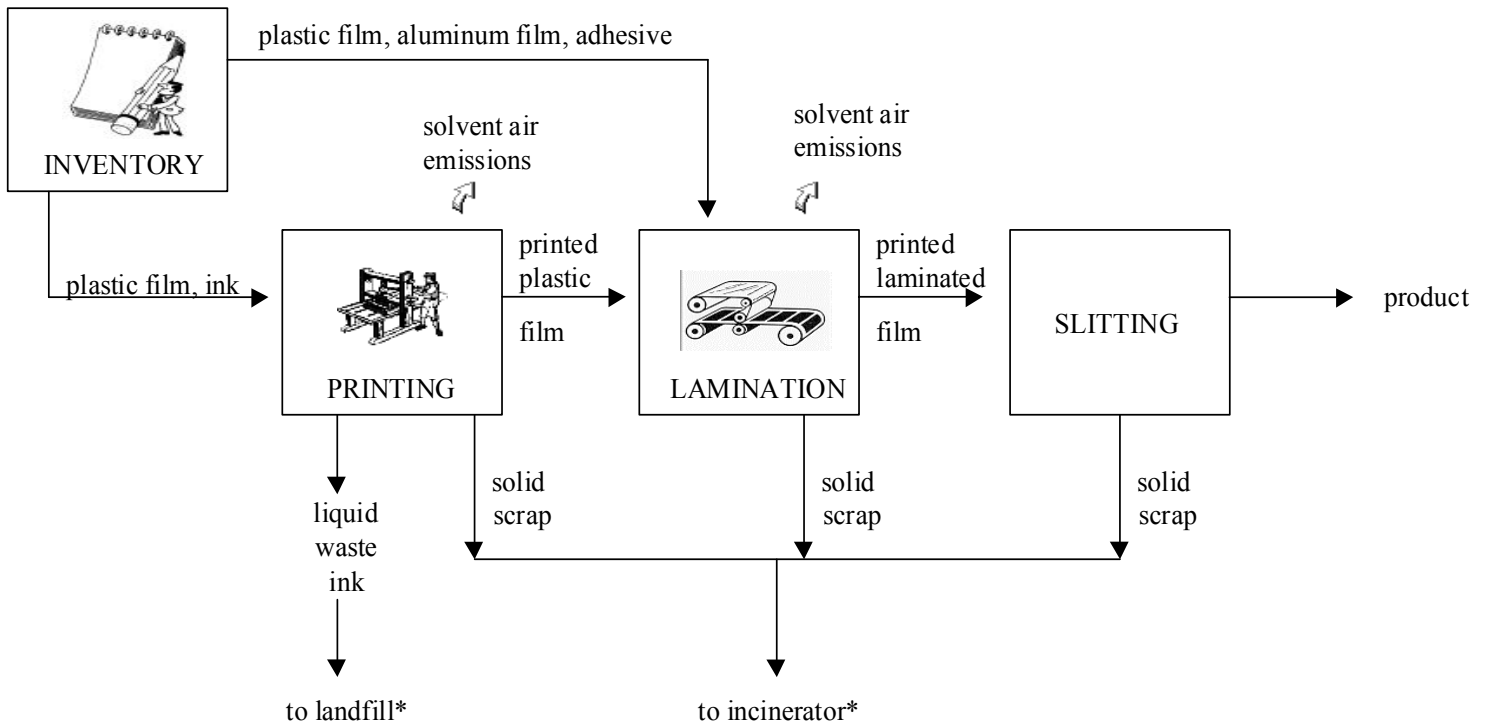
pollutants, including oil and grease that probably result from the inefficient burning of plastic at a low temperature.

PLS has started using a fuel additive along with the incinerator diesel fuel to make the incineration process more efficient. The fuel additive is expensive but pays off by lowering overall fuel requirements. The more efficient combustion also has reduced the levels of some pollutants in the scrubber water.

In the past, the wastewater from the incinerator scrubber was disposed of into a nearby stream. This practice recently triggered non-compliance fines from the government because high levels of oil and grease in the wastewater exceeded regulatory limits. In response, PLS started sending the incinerator scrubber water to an existing on-site wastewater treatment plant (WWTP), which brings the oil and grease levels down to an acceptable level before sending the final effluent to the stream. The WWTP was originally designed to handle wastewater streams from other parts of the facility. However, the major flow to the WWTP now is the incinerator scrubber water.

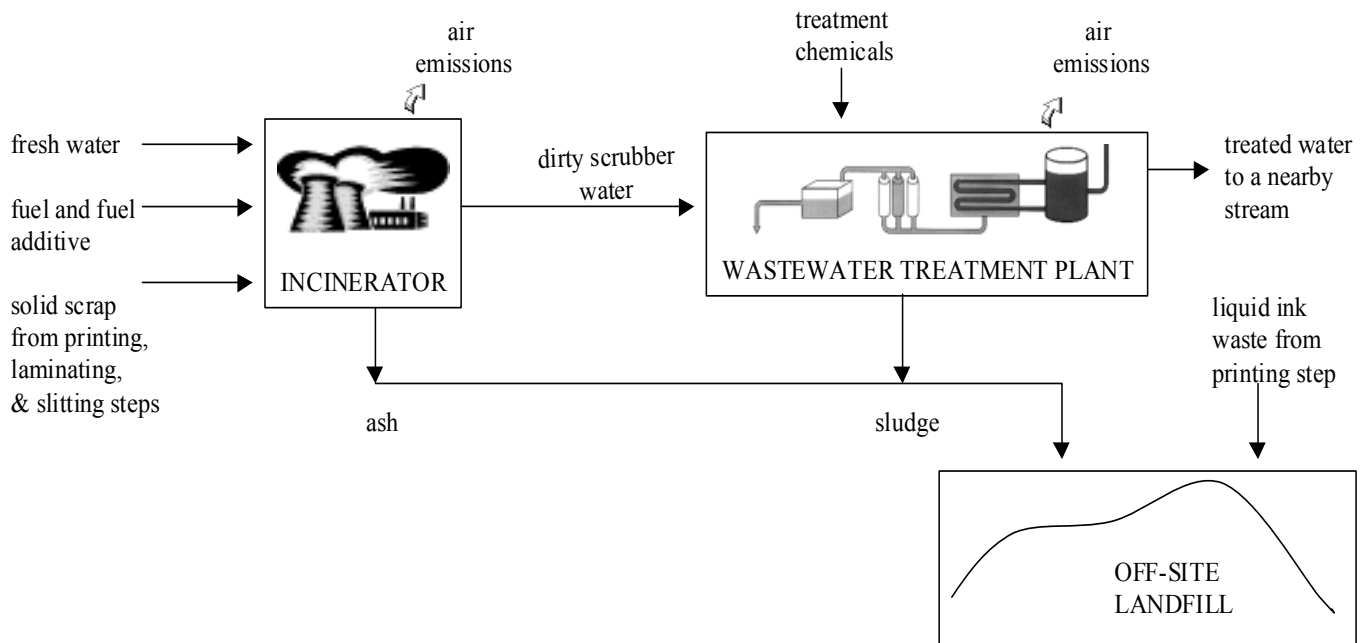
Both ash from the incinerator and the sludge resulting from wastewater treatment are sent by truck to an off-site landfill.

Figure 1: Manufacturing Steps at the PLS Company— Materials Flow Map



*see next map for details

Figure 2: Solid Scrap Management at the PLS Company— Materials Flow Map





Small Group Exercise

“Cost Estimation at the PLS Company”

Objective

The generation of pollution or waste by business operations can be quite costly. This is true for both large and small firms, and applies to diverse business sectors, including service and resource extraction sectors as well as manufacturing sectors. The objective of this exercise is to give you the opportunity to think about a couple of common costs that result from waste generation at the PLS Company, and how you might estimate those costs.

Instructions

Question 1 gives you some data from the accounting records and asks you to calculate the purchase value of lost raw materials due to the generation of solid scrap at PLS. Work in small groups to answer Question 1 as best you can.

When you finish Question 1, proceed to Question 2. Company Question 2 asks you to think about how to identify and estimate labour costs for the PLS incinerator and wastewater treatment plant, about which there is not much information in the accounting records.

After about 30 minutes, the small groups will discuss their answers with each other and with the instructor.

Question 1 (20 minutes)

As a first step, try to estimate *the total purchase value of plastic and aluminium film that are lost as scrap* at the PLS Company, using the data given below. PLS does not measure the waste generation rates for solid scrap— but you can calculate the scrap amounts from information found in the accounting records.

Use the given data from the PLS accounting records to estimate the total lost purchase value of plastic and aluminium film from all three manufacturing steps at PLS. In order to make the data easier to understand, it would be a good idea to record the film input and output data on the PLS materials flow map, i.e., record the data for each manufacturing step at that step on the map. This will help you visualise how to calculate the scrap amounts. You will need to re-read the description of the PLS Company’s Manufacturing Steps carefully in order to do this exercise.

Film Inputs and Outputs for Each Manufacturing Step (km/year)

Manufacturing Step	Virgin Plastic Film Input	Virgin Aluminium Film Input	Product Output
Printing	26,016	0	24,496 (full width)
Lamination	24,496	24,496	24,154 (full width)
Slitting	0	0	71,934 (slit width) which is equivalent to 23,978 (full-width)

Purchase Prices for Plastic and Aluminium Film (US\$)

Input	Unit Cost
Plastic Film	\$ 34 /km
Aluminium Film	\$ 66 /km

Question 2 (15 minutes)

Waste management costs are not as easy to find in the PLS accounting system as direct manufacturing costs. For example, you know that a number of different PLS employees spend at least part of their time on activities related to the handling, treatment, and disposal of solid scrap at the facility, as well as related regulatory compliance activities. However, the accounting records at PLS do not specify which employees.

Even for employees who obviously spend time on waste management activities, e.g., the pollution control officer (PCO), the accounting records do not specify the amount of time spent on solid scrap activities vs. unrelated activities, e.g. handling hazardous waste ink or monitoring solvent air emissions at the facility.

Use the blank space below to take some notes on your answers to the following questions:

- In addition to the PCO, who else would probably be involved in waste management activities related to solid scrap at PLS?
- Now that you have identified the PLS staff involved in managing solid scrap at PLS, what systematic approach would you use to identify all of actual waste management activities that they spend their time on?
- How would you actually estimate the associated labour costs?



Small Group Exercise

“Profitability Assessment at the PLS Company— Part I”

Overview

The PLS Company bought a quality control (QC) camera system and installed it on the print line. Full production run printing errors could then be detected earlier than was possible without the cameras. The project reduced the scrap rate from full production runs by about 40% and reduced annual operating costs accordingly.

The objective of this exercise is to conduct a profitability assessment for the project using two different profitability indicators. It is important to understand the advantages and disadvantages of each indicator so that you can accurately characterise and interpret a project's profitability. This exercise is broken up into two parts.

Part I— Part I first asks you to calculate the annual cash flows of the printing step both before and after implementation of the QC camera project. This will allow you to calculate the annual savings that resulted from the installation of the QC camera. Finally, you will estimate project profitability using an indicator called “simple payback”.

Part II— In preparation for Part II of the exercise, you will first hear a lecture on the concepts of “The Time Value of Money” and “Net Present Value (NPV)”. Then you will be asked to calculate the NPV for the QC Camera project – another profitability indicator. You will then compare the two indicators you have calculated, i.e., simple payback (from Part I) and NPV (from Part II), to see what they tell you.

Part I— Cash Flow and Simple Payback

Question 1: Calculation of annual cash flows (15 minutes)

You will first need to calculate the annual operating costs associated with the manufacturing inputs to the print step as well as waste management costs for the solid scrap waste from the print step. These costs need to be calculated both before installation of the QC camera ("Business as usual"), and after installation of the QC camera. Then the annual savings, i.e., reduction in annual operating costs, can then be calculated.

Use the materials balance information and the Cash Flow Worksheet given on the following page to calculate the "before" and "after" operating costs for the project. At the bottom of the worksheet, calculate the total annual operating costs "before" and "after" installation of the QC camera. Finally, calculate the total savings for the project, i.e., the total reduction in operating costs.

Question 2: Calculation of Simple Payback to evaluate profitability (5 minutes)

Simple Payback represents the number of years it will take for the cash inflows from an investment project to "pay back" the initial investment. It is calculated by dividing the total initial investment by the first-year savings from the project.

$$\text{Simple Payback} = \frac{\text{Initial Investment}}{\text{First - year Savings}}$$

The total initial investment cost for the QC camera system (for purchase, installation, and employee training, etc.) is US\$ 105,000. Use the annual savings calculated in Question 1 above to calculate Simple Payback for this project.

PLS uses a Simple Payback hurdle rate of three years. In other words, if the Simple Payback for a project is less than three years, then PLS considers the project to be profitable. Based on the Simple Payback you calculated, is the QC camera project profitable or not?

Print Step Materials Balance

Item	Business as Usual, i.e., BEFORE QC Camera System	CP Alternative, i.e., AFTER QC Camera System
Virgin film input	26,016 km/year	25,742 km/year
Full-run scrap rate	684 km/year	410 km/year
Print step output	25,332 km/year	25,332 km/year

Cash Flow Worksheet

Cost of manufacturing inputs			
Cost Item	Unit Cost (US\$ /km virgin film used)	Business As Usual (US\$ /yr)	With QC Camera (US\$ /yr)
Direct labour	\$2.50		
Direct energy	\$4.25		
Ink	\$71.00		
Plastic film	\$34.25		
SUBTOTAL (manufacturing inputs)			
Cost of incinerator operation			
Cost Item	Unit Cost (US\$ /km scrap burned)	Business As Usual (US\$ /yr)	With QC Camera (US\$ /yr)
Fuel	\$3.00		
fuel additive	\$6.50		
Labour	\$14.20		
trucking ash to landfill	\$0.70		
SUBTOTAL (incineration)			
Cost of wastewater treatment plant operation			
Cost Item	Unit Cost (US\$ /km scrap burned)	Business As Usual (US\$ /yr)	With QC Camera (US\$ /yr)
Chemicals	\$0.30		
Electric power	\$1.30		
Labour	\$2.30		
Trucking sludge to landfill	\$0.08		
SUBTOTAL (wastewater treatment)			
TOTAL COSTS = (manufacturing inputs + incineration + wastewater treatment)		Before	After
ANNUAL SAVINGS (Before – After) =			



Small Group Exercise

“Profitability Assessment at the PLS Company— Part II”

Part II— Net Present Value (NPV)

Question 3: Calculation of NPV to evaluate project profitability *(15 minutes)*

Question 2 asked you to calculate the Simple Payback indicator to assess the profitability of the QC camera project. Net Present Value (NPV) is another profitability indicator that is a bit more complicated to calculate than Simple Payback, but can be more reliable and accurate.

Recall that the definition of NPV is:

NPV_n = the sum of the present values of all project cash flows over the first n years

For example:

NPV_3 = the sum of the present values of all project cash flows over the first 3 years

Recall that if the NPV for a project is greater than zero, the project is considered to be profitable over the time period of interest. If NPV is less than zero, the project is considered to be NOT profitable over that time period. See the attached handout entitled “Performing Net Present Value (NPV) Calculations” for assistance in doing the NPV calculation.

The average discount rate for investment projects at the PLS company is 15%. Use this discount rate to calculate NPV_3 for the QC camera project.

Based on the NPV you calculated, would you say that the QC camera project is profitable by the end of three years? Or not profitable?

Question 4: Compare Simple Payback and NPV (5 minutes)

You have now calculated both Simple Payback and NPV₃ for the QC camera project. Record your results in the table below, and compare the results from the two indicators. What do you think about the relative value of Simple Payback and NPV as profitability indicators?

Profitability indicators for the QC camera project

Profitability Indicator	The Value you Calculated	Hurdle Rate	Profitable or not?
Simple Payback (yrs)		3 years	
NPV ₃ (US\$)		zero	

