SCORE

SUSTAINING COMPETITIVE AND RESPONSIBLE ENTERPRISES

Module Three

Productivity through Cleaner Production

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Preface

Sustaining Competitive and Responsible Enterprises

This manual is a part of the ILO SCORE programme that is a response to the conclusions reached by the governments, employers and workers at the International Labour Conference in 2007. In the discussion on sustainable enterprises they concluded that:

"Sustainable enterprises need to innovate, adopt environmentally friendly technologies, develop skills and human resources, and enhance productivity to remain competitive in national and international markets. They also need to apply workplace practices based on full respect for fundamental rights at work and international labour standards, and foster good labour-management relations as important means of raising productivity and creating decent work. These principles are applicable to all enterprises."

The ILO SCORE programme is a practical training and workplace support programme designed to increase the productivity of small to medium sized enterprises while promoting recognition of, and respect for workers rights. The objective is to deliver best international practice linked to the development of mature workplace relationships that promote productivity and enhanced wages and conditions for workers. Areas the programme focuses on include workplace cooperation, quality management, cleaner production, occupational safety and health, and human resource management.

This third module focuses on improving productivity through clean production approaches that seek to utilize energy, water, material, and chemical resources more efficiently while also reducing pollution and wastes.

The SCORE manuals build on the knowledge and experience built up in the former ILO – Factory Improvement Programme implemented in Asia. Many authors have contributed to this manual: Stephan Ulrich and Michael Elkin from the ILO SCORE programme guided and managed the development of Module 3. Athena Bertolino, Tim Larson, Darcy Peth, and Jennifer Tice at Ross & Associates Environmental Consulting (www.ross-assoc.com) were the primary authors of the Module. Professor Christoph Hugi and Dirk Hengevoss at the University of Applied Science, Northwestern Switzerland provided helpful review and input on the Module. Module 3 draws on materials developed by the United Nations Industrial Development Organization (UNIDO), particularly in Chapters 1 and 5. The Module also draws on resources developed by Ross & Associates for the United States Environmental Protection Agency's Lean & Environment Initiative (www.epa.gov/lean), particularly in Chapters 1 and 6.

Table of Exercises

1 Introduction to productivity through cleaner production

1.1 What is cleaner production?

Cleaner Production (CP) is a strategy to **reduce environmental pollution and simultaneously reduce consumption of resources**. Its main focus is on processes and on reduction of losses, following the objective of minimizing input (resources such as labour, materials, capital, and energy) while maximizing output (the end product that gets sold and makes the enterprise money). CP extends well beyond technical fixes, and is an integrative view of the issue that does not isolate or concentrate on just one aspect of the problem. CP emphasizes efforts to prevent the generation of wastes and unnecessary use of resources, turning to end-of-pipe pollution controls and treatment only as a last resort. CP can be thought of in three main parts:

1. **Prevention and minimization** – avoiding the production of waste and ensuring the efficient use of resources
2. **Reuse and recycling** – recovering materials and wastes for productive use
3. **Clean and efficient energy** – maximizing productivity of energy inputs while minimizing pollution

How does cleaner production relate to productivity?

Productivity is the relationship between inputs and outputs. For a long time it was thought that increasing productivity meant getting the workforce to work faster or harder in the way it operated. However, this focus on labour productivity missed important opportunities to improve material and resource productivity through the use of better machines, processes, technologies, product designs, and work practices. In addition, the sole focus on labour productivity ignored opportunities to eliminate things that distract or prevent workers from adding value, such as unsafe and unhealthy workplaces that cause injuries and illnesses.

Productivity improvement through better utilization of the energy, materials, water, solvents, etc. is now seen as an effective tool in preventing pollution at source. This modern approach still aims for the efficient use of resources and increasing output, but focuses on **working smarter rather than harder**. This means that managers now focus on adding greater value to the work of their employees rather than just increasing the quantity of work that is done. Using this approach, improving productivity involves:

- Improving the overall business environment;
- Developing better communication between management and workers;
- Improving the design of the product;
- Improving the processes that produce the product; and
- Improving the skills of all members of the workforce.

All aspects of an organization can affect productivity. If human resources are not managed properly then there can be over or understaffing which reduces productivity levels. If health and safety is not continuously considered then productivity suffers from accidents, damaged equipment, or lost work days due to illness.

Which of these looks like a cleaner, safer place to work?

CP seeks to improve productivity—increasing the value of outputs with fewer inputs. CP focuses attention on improving resource and material productivity, helping an enterprise get more value out of inputs used. Profit increases if the enterprise can deliver a quality product or service to a customer while using fewer materials, chemicals, energy. If the enterprise can prevent or effectively manage wastes and pollution, the enterprise is able to focus its people and resources on activities that add value to the customer. CP also complements efforts to enhance labour productivity by creating a healthy workplace that is free of chemical and pollution hazards. To achieve its objectives, CP utilizes a range of tools and methods which are discussed further in this module.

Lean and clean manufacturing principles

Lean manufacturing, and related approaches such as Six Sigma and continuous improvement, are well aligned with CP – all focus on the identification and elimination of waste. Lean manufacturing refers to a customer-focused business model that focuses on the identification and elimination of waste while delivering quality products on time and at a low cost. Waste is defined as any activity or input that does not add value to the customer.

Lean typically targets seven areas which have significant potential to decrease productivity and generate waste:

1. Overproduction
2. Inventory
3. Transportation
4. Motion
5. Defects
6. Over processing
7. Waiting

Environmental waste, the main target of CP and sometimes referred to as the "eighth waste" in Lean processes, is an unnecessary or excess use of resources or a substance released to the air, water, or land that could harm human health or the environment. Environmental wastes can also directly affect production flow, time, quality, and cost – making them inherently connected to Lean and CP wastes and initiatives. In many cases, the costs to the enterprise and society associated with pollution and wasted energy, water, and raw materials can be significant.

Use of the term "waste"

The term "waste" can often have different meanings in different manufacturing contexts. In Lean manufacturing, people tend to use the word waste to describe the seven target areas listed on this page, often referred to as the seven "deadly" wastes. In doing so, they often do not consider environmental waste. In the context of CP, all waste areas are generally considered environmental waste. If your facility routinely uses the term waste to describe the lean deadly wastes, it is important consider expanding the definition of waste to include (and target) environmental waste.

A significant competitive advantage can be attained by providing customers with products and services with less environmental impacts.

Practically speaking, environmental wastes include:

- **Energy, water, or raw materials** consumed in excess of what is needed to meet customer needs.
- **Pollutants and material wastes** released into the environment, such as air emissions, wastewater discharges, hazardous wastes and solid wastes (trash or discarded scrap).
- **Hazardous substances** that adversely affect human health or the environment during their use in production or their presence in products.

Like the seven wastes of Lean, environmental wastes do not add customer value. The table below lists environmental impacts that are associated with the deadly wastes targeted by Lean methods. By reducing these production wastes through Lean efforts, you can improve your enterprise's environmental performance and overall productivity. Several chapters in this Module explore practical steps for using specific Lean tools such as 5S, standard work/ operating procedures, total productive maintenance, visual controls, and right-sizing to reduce CP wastes and risks. These Lean tools are organizational improvement methods pioneered in the Toyota Production System.

Area of Waste Generation	**Environmental Impacts**

Overproduction	• More raw materials and energy consumed in making the unnecessary products • Extra products may spoil or become obsolete requiring disposal • Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.
Inventory	• More packaging to store work-in-process (WIP) • Waste from deterioration or damage to stored WIP • More materials needed to replace damaged WIP • More energy used to heat, cool, and light inventory space
Transportation and Motion	• More energy use for transport • Emissions from transport • More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption • More packaging required to protect components during movement • Damage and spills during transport • Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents
Defects	• Raw materials and energy consumed in making defective products • Defective components require recycling or disposal • More space required for rework and repair, increasing energy use for heating, cooling, and lighting
Over processing	• More parts and raw materials consumed per unit of production • Unnecessary processing increases wastes, energy use, and emissions
Waiting	• Potential material spoilage or component damage causing waste • Wasted energy from heating, cooling, and lighting during production downtime

Exercise 1: Thinking about environmental wastes

Name five examples of environmental wastes you could reduce at your company.

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1.2 Why implement cleaner production?

By implementing cleaner production activities you will:

Improve business performance by improving productivity and reducing costs

Environmental wastes are often a sign of inefficient production, and they frequently indicate opportunities for saving cost and time. For example, the chemicals and hazardous materials used in a process often require costly support activities, such as regulatory compliance management and reporting activities, and use of personal protective equipment and pollution control equipment. These activities do not add value to the customer, and they create unnecessary risks to employee health and safety. When chemical or material inputs expire or spoil before being used, enterprises waste money twice—paying for inputs that are not used and then paying to dispose of these inputs as wastes. Similarly, the unnecessary or inefficient use of energy, water and materials is a direct cost that lowers profits. Learning to see and eliminate hidden environmental wastes can greatly reduce costs and improve productivity.

Be perceived as an environmentally responsible enterprise

In many business sectors, customers—both consumers and other companies—demand or give preference to suppliers that demonstrate superior environmental and social responsibility and performance. Some companies even require that suppliers obtain certification of their environmental or human resource management systems. For example, some companies require suppliers to comply with International Standards Organization (ISO) environmental or energy management system standards (e.g., ISO 14001). Implementing CP may help an enterprise capture new market opportunities as it systematically works to improve its environmental performance.

Most customers who purchase products do not want to buy environmental wastes, impacts, or risk. **Companies that can deliver products and services with fewer environmental impacts have the potential to capture significant competitive advantage**. In many markets products with superior environmental performance can attract new customers. For example, enterprises implementing CP may also generate product design improvement ideas that can save customers energy or water when they use the product or can reduce customers' exposure to toxic chemicals in the product—increasing the value of the product.

Be a responsible employer and attractive place to work

CP can also improve the work environment for employees. Eliminating environmental hazards can reduce potential employee exposure to toxic substances and create a cleaner and safer workplace. In addition, employees want to do the right thing. When employees take pride in their work because they believe it has broader benefits to their community and the world, there can be a substantial positive effect on organizational morale. This can empower employees, further enhance productivity, and attract a skilled and motivated workforce.

Improve the quality of life in your community

CP also enables an enterprise to improve the quality of life in the local community. Wastes and pollution can harm local environmental quality – fouling the air employees and neighbours breathe and the water they drink. Wastes and pollution can also disrupt local ecosystems and affect the productivity of local agriculture and fisheries on which a community may depend. Furthermore, efforts to reduce the costs associated with wasted resources and pollution can put more money in the pockets of enterprises and employees, enhancing local development and prosperity.

Exercise 2: Benefits of implementing cleaner production

How could your company benefit from improved environmental performance? (Think about time and cost savings, reduced risks and liabilities, increased employee morale, added value to customers, etc.)

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Case Study: Cutting energy use and boosting productivity

Nguyen Hoang Exim Co was established in 1992 as a private company, located in Hung Yen Province outside of Hanoi, Vietnam. The company primarily produces work clothing and some ladies wear for export and employs 500 workers in the factory. Nguyen Hoang uses great amounts of energy in all its production processes. Prior to implementing cleaner production methods, the factory only had a single electricity meter that measured total consumption. It was not possible, therefore, to analyze electricity consumption by production and non-production usage, nor to identify areas of inefficiencies or wastage. It was also not possible to allocate costs to departments or with regard to production. The factory had little understanding of its electricity consumption. In addition, Nguyen Hoang has a very large requirement for hot water and steam in its production process. Steam is primarily used for irons to press the garments during and at the end of the production process. In order to minimize costs and environmental impact it is important that the factory ensures the most efficient steam production system. It was decided that the system in use at Nguyen Hoang suffered from high levels of sediment; insufficient insulation; the fan used to generate oxygen to feed the fire was inefficient and the heat transfer during the condensation process was not being capitalized on.

Actions taken by the factory

Management agreed to implement the following cleaner production actions:

- Sediment that had collected at the bottom of the boiler and in the heat transfer pipes was cleaned out;
- The pipes carrying the steam were insulated to reduce heat loss;
- The boiler fan was reset to ensure that it provided the correct amount of air to allow the coal to burn efficiently;
- A regular program of monitoring and cleaning the steam production system was designed and implemented; and
- Two electricity meters were installed.

Management is also evaluating two options with regard to condensing steam back to water.

Impact of changes

Implementation of the two electricity meters was successful, resulting in both a reduction of electricity consumption and changes in attitude and behavior. The fact that the meters have been installed has made the staff and workers much more aware of how their behavior has an impact on energy consumption. The administrative staff, in particular, is more conscientious about turning off lights, turning down the air-conditioning and using fans rather than air-conditioning. The average monthly energy consumption in the first half of 2007 was 16% less than in 2006. Having seen the savings that the first set of meters have made, the company plans to install additional meters in the warehouse and groundwater pump station. In addition, the average monthly consumption of coal during 2007 reduced by 24.5% against 2006. Conversely, the output per tonne of coal burned is dramatically different to that achieved prior to the changes - in June 2007 the boiler was producing 11,875 litres of boiled water per tonne of coal in comparison to an average of 8,641.98 litres per tonne in 2006. This is a 37.41% improvement in energy efficiency against the average for 2006.

1.3 How do you implement cleaner production?

Some environmental wastes are easy to see. Containers of solid and hazardous waste are visual indications of environmental waste. Health and environmental risks posed by certain chemicals or materials can be more difficult to see, although they can represent costly non-value added aspects of a process or product. Environmental wastes can be found in almost any process. Processes requiring environmental permits – such as painting, metal finishing, and hazardous waste management processes – are often a good place to look for environmental improvement opportunities.

Following are steps to take in implementing CP. By implementing CP actions, you will learn how to manage a continuous improvement of environmental performance of machinery and processes while encouraging economic growth at your facility. The remaining chapters in this module go into more detail for each of these steps:

- **Assess** the current situation and identify opportunities to reduce or eliminate waste and risks as well as make them visible [focus of Chapters 2 and 4]
- **Analyze** problems/opportunities and identify and prioritize options [focus of Chapter 6]
- **Conduct** effective and efficient implementation by engaging all levels at your company [focus of Chapters 3, 6, and 7]
- **Build** capacity for continuous improvement [focus of Chapters 3 and 5]

2 Material and resource wastes: targets for CP

2.1 Energy use

Installing efficient lighting

Energy is an important and increasingly costly input in most enterprises. Inefficient use of energy – or the use of dirtier energy sources – can affect your enterprise's success in several ways. High or volatile costs for electricity or fuels can erode profit or weaken competitiveness. In some places, excessive energy use can even contribute to shortages that affect the reliability of energy supplies. Burning fossil fuels – such as coal, diesel, and fuel oil – releases multiple pollutants into the air which affect human health and contribute to environmental challenges such as climate change and acid rain.

CP addresses energy in two ways: 1) energy efficiency and 2) use of cleaner energy sources. Energy efficiency looks at the various ways energy is used in the enterprise to identify ways to use less energy to accomplish the same or better result. The ways in which energy is used is often called "energy end uses."

WHAT DO WE USE ENERGY TO DO?
COMMON ENERGY END USES

- ✓ Heating, ventilating, and air conditioning (HVAC) in buildings
- ✓ Lighting
- ✓ Process equipment operation
- ✓ Process heating and cooling
- ✓ Transportation

Use of cleaner energy sources looks for ways to substitute energy sources that produce less pollution, such as natural gas, wind or solar energy, to replace dirtier energy sources, such as burning coal or high sulphur fuel oil.

Answering the following questions will help you understand energy use at your facility and identify areas for improvement.

- What are the major energy end uses in your enterprise?
- What sources of energy (electricity or fuels for on-site combustion) do each of these end uses rely on?
- Where are the sources of waste heat?

The box below lists questions that are specific to different types of energy end uses that can be helpful to identify CP improvement opportunities. As you look through the questions, consider which questions you might answer "yes" to and

what actions you might take to address the opportunity. Your answers in this chapter will inform many of the exercises throughout this manual.

COMMON ENERGY OPPORTUNITIES	Y/N?	ACTION TO BE TAKEN
Facility Heating and Cooling ✓ Can you control the level of heating, cooling, and ventilation in your buildings? ✓ Can you set thermostat temperatures so that work areas are not heated or cooled more than necessary? ✓ Can you keep windows or doors open or closed to prevent the use of unnecessary space heating and cooling? ✓ Can you improve maintenance on HVAC systems (e.g., changing or cleaning air filters) to make them run more efficiently? ✓ Can the fuel source for on-site boilers be changed to a cleaner burning fuel? ✓ Can the waste heat from HVAC-system be used for heating purposes? ✓ Can pipes and the building shell, windows, doors etc. better be insulated?		
Lighting ✓ Can lighting be better focused where workers need it and in the amount that they need? ✓ Can daylight be used for lighting? ✓ Can you replace incandescent lighting with more efficient fluorescent, LED, or other lighting? ✓ Can you install motion sensors or take other steps to turn off lights in warehouses, storage areas, and other areas that are intermittently used? ✓ Can you work with your electric utility to assess your lighting systems to determine if efficiency upgrades are useful?		
Process Equipment Operation (Motors and Machines) ✓ Can machines be turned off when not in operation? ✓ Must the circulation pumps run all the time? ✓ Can more energy efficient motors, pumps, and equipment be used? Can you switch to more efficient motor systems that use variable		

speed drive controls? ✓ Can motors, pumps, and equipment be better sized according to their loads? ✓ Can the production planning be optimized to reduce non-productive operation time of production equipment? **Process Equipment Operation (Compressed Air)** ✓ If a compressed air is used, can you routinely find and repair leaks in the compressed air system? ✓ Can you reduce the pressure in the compressed air system and still operate equipment effectively? ✓ Can the waste heat from the compressor be used for heating purposes? **Process Heating and Cooling** ✓ Can process heating temperatures (e.g., used in ovens) be effectively maintained at lower levels? ✓ Can other steps be taken to avoid the unnecessary loss of heat or coolness in the process (e.g. waste gas heat recovery)? ✓ Can you improve maintenance on boilers and refrigeration systems? **Transportation** ✓ Can you switch to more fuel efficient vehicles for business transportation needs? ✓ Can you run forklifts in the facility on electricity/batteries or compressed natural gas/propane instead of other dirtier fuels? ✓ Can you improve maintenance of vehicles so they run at optimal fuel efficiency (e.g., maintaining tire pressure, replacing air and fuel filters)? ✓ Can you provide incentives for employees to walk or bike to work (e.g., providing places to lock and store bikes, providing showers and lockers, rewards)? ✓ Can you provide incentives for employees to take public transit to work (e.g., providing subsidized transit passes, charging for parking and using the funds to reward use of transit or bikes to commute)?		

2.2 Water use

Water is a vital resource to enterprises and people. Increasingly, reliable access to clean freshwater is becoming a greater concern in many areas throughout the world. In many areas, water in rivers, lakes, and underground aquifers is being siphoned off at rates that exceed natural replenishment rates. Some freshwater supplies are being contaminated by industrial pollution, agricultural chemicals and animal wastes, or sewage. Furthermore, global climate change is shifting precipitation and snow melt patterns in ways that are making areas more vulnerable to freshwater shortages, drought, and contamination resulting from natural disasters. These and other factors mean that the availability of freshwater is declining at a time when demand is increasing due to population and economic growth.

Water scarcity can affect enterprises in several ways. First, as pressures on local water supplies increases, the price of water may increase, directly affecting input costs. Second, even when water prices are low, water supplies can be disrupted during water shortages, paralyzing water-dependent processes and activities. Third, water costs and shortages can affect suppliers and customers, affecting input costs and availability as well as customer demand.

By learning to use water more efficiently, enterprises can reduce costs associated with water use while also lessening demand pressures on local water sources that can threaten water availability. "Water efficiency" means using improved technologies and techniques to achieve the same results using a decreased supply of water. These strategies are essential in order to cope with the risk of water restrictions in many areas in the future. Already in industrial, commercial and institutional sectors across the globe, water efficiency programs are being instituted to achieve cumulative water savings in a way that is cost-effective.

TYPES OF WATER EFFICIENCY MEASURES

- ✓ Metering of usage (e.g., knowing where most water use occurs)
- ✓ Reducing losses (e.g., fixing leaks)
- ✓ Reducing total water use (e.g., shutting off water when not needed, using efficient applications such as low water volume flushing toilets and drip irrigation)
- ✓ Employing water reuse practices (e.g., reusing rinse water, closed loop cooling systems)
- ✓ Using grey/rain water

Answering these questions will help you to identify areas of water waste in your enterprise, as well as areas for improvement.

- What are your facility's primary uses of water?
- What sources of water (e.g., a local river, lake, or aquifer) does your facility draw water from? Is there a risk of water scarcity in your region, either now or in the future?

- What are your enterprise's major uses of water? Consider cooling and heating, domestic and sanitation uses, process rinsing, cleaning activities, kitchens, laundries, landscaping, and others.
- Is water use a major issue "upstream" to your enterprise? Do any inputs to your production require significant water use?
- Are there any important water use issues "downstream" from your enterprise? Do your products or services require customers or others to use or have access to water?

Water use in most industries can be classified into the following broad end uses: sanitation (restrooms), heating/cooling, processing/cleaning, and landscaping. These common end uses represent the best opportunities for a facility to examine in order to reduce their water use. Questions in the following box help to identify CP improvement opportunities related to water.

COMMON WATER OPPORTUNITIES	Y/N?	ACTION TO BE TAKEN
Sanitation ✓ Have low-flow, water-efficient toilets been installed at the enterprise? ✓ Do all faucets and showerheads have low-flow aerators installed to reduce water use in sinks? **Heating/Cooling** ✓ Has once-through cooling water used in air conditioners, air compressors, vacuum pumps, etc. been eliminated with the use of chillers, cooling towers, or air-cooled equipment? ✓ Has blow-down/bleed-off control on boilers and cooling towers been optimized? ✓ Is condensate being reused? **Process Rinsing and Cleaning** ✓ Have improved rinsing techniques been implemented, such as counter-current systems, sequential use form high quality to lower quality needs, conductivity flow controls, improved spray nozzles/pressure rinsing, fog rinsing or agitated rinsing? ✓ Is water turned off when not in use by flow timers, limit switches, or work practices? ✓ Is the life of water (aqueous) baths being maximized using filtration and		

maintenance controls? ✓ Are "dry clean-up" practices used instead of using hoses to clean with water? If water washing is necessary, is first-pass pre-cleaning conducted with squeegees, brushes, or brooms? ✓ Can flow restrictors be used to limit water use? **Process Water and Water Systems** ✓ Is water conveyed in straight pipes (with few bends) to reduce energy demands for pump motors? ✓ Are pipes and equipment that convey or use water routinely checked for leaks? **On-Site Water Reuse** ✓ Is water quality matched with water quantity? Can rainwater, rinse water, or other non-potable sources of water be captured and reused for certain purposes? ✓ Have reuse applications been examined for process water, landscaping irrigation, ornamental ponds, flush water and cooling towers? **Landscaping** ✓ Can the amount of water used for landscaping be reduced? ✓ Can steps be taken to lower landscaping water use, such as using low-flow sprinklers, trickle/drip irrigation, optimized watering schedules and water placement, and preventive maintenance? ✓ Can the type of plantings or landscaping (e.g., xeriscaping techniques) be used to reduce or eliminate the need for supplemental watering? **Examples for Kitchens** ✓ Are "electric eye" sensors for conveyer dishwashers installed? ✓ Have new water and energy efficient dishwashers been installed? *Source: Adapted from North Carolina Department of Environment and Natural Resources. Water Efficiency Manual*		

for Commercial, Industrial and Institutional Facilities. May 2009.		

2.3 Material and chemical use

Use of materials and chemicals varies substantially across sectors and production processes. Purchases of material and chemical inputs can be a major cost for many enterprises. By reducing the amount of material and chemical inputs needed per unit of production, an enterprise lowers costs and reduces its environmental impact, and therefore, improves productivity. In some cases, reducing the use of material and chemical inputs may have the added benefit of reducing health risks to workers, neighbors, and customers.

There are four common methods to reduce the use of material and chemical inputs:

Reduce scrap. Many production processes do not fully use material inputs, leaving scrap materials that need to be discarded or recycled. Consider opportunities to reduce the amount of scrap that is generated by the process.

Reduce unused materials. Some materials and chemicals are purchased in bulk and never used. They may expire, spoil, or become damaged or obsolete, causing an enterprise to pay for them twice—first to purchase and then to dispose. Consider opportunities to purchase materials as needed and protect them from spoilage or damage during storage and handling.

Dematerialize product design. Not all materials in products are needed to add value to customers. Consider opportunities to work with product designers to reduce the materials in products while maintaining product quality and performance.

Identify by-products. Waste output from production often is a useful input material for other industries. Consider opportunities to sell your waste as by-product to other industries.

While the actions above focus on reducing the quantities or volume of materials used, one additional strategy is useful to lower the risk and impacts of materials to human health and the environment: **substitution**. Substitution involves replacing one material or chemical with another that has fewer environmental and public health impacts. Increasingly, customers may also be concerned with the lifecycle impacts of materials or chemicals. Lifecycle impacts involve considerations beyond an enterprise's fence—addressing impacts associated with the production or extraction of raw materials as well as from a customer's use or disposal of the product. For example, some raw materials may have high greenhouse gas emissions associated with their production; the use of mercury in products may pose unacceptable risks or disposal costs to customers

who buy and use the products. It is important to note that a variety of factors—cost, availability and reliability of supply, customer specifications, and quality—must be considered when exploring material and chemical input options. Questions in the following box help to identify CP improvement opportunities related to material and chemical use.

COMMON MATERIAL AND CHEMICAL USE OPPORTUNITIES	Y/N?	ACTION TO BE TAKEN
Reduce Scrap ✓ Can you purchase material inputs in a size or configuration that reduces the amount of scrap created? ✓ Can you adjust process equipment or production patterns to optimize use of materials and reduce scrap? ✓ Can scrap materials be reused or recycled within the enterprise? ✓ Are there other enterprises that might be able to use the scrap as a material input?		
Reduce Unused Material ✓ Can you reduce material inventories or shift toward "just-in-time" purchasing, particularly where materials often go unused? ✓ Can you purchase materials in "right-sized" containers (see Chapter 5.3) to better ensure purchased materials are actually used? ✓ Can you "kit" (or package materials and chemicals in "right-sized" portions) so that employees take and use only what is needed? ✓ Can you improve material storage and labeling to ensure that the oldest stock is used first to minimize spoilage and expiration? ✓ Can you improve material handling practices to ensure that materials are not damaged or spilled?		
Dematerialize Product Design ✓ Can you work with product designers (with the enterprise or customer) to identify opportunities to reduce the materials used in a product?		

✓ Can you identify opportunities to reduce the materials used in product packaging? **Substitute Materials** ✓ Can you substitute materials or chemicals with lower environmental or public health impacts? ✓ Can you increase the use of recycled materials in products or packaging?		

2.4 Pollution and waste

CP also seeks to minimize the generation of pollution and wastes. There are several compelling reasons for enterprises to reduce pollution and wastes. First, pollution and wastes typically result in numerous direct and indirect costs to enterprises (see the textbox below). Second, pollution and wastes – sometimes referred to as non-product output – often represent an inefficient use of input resources. Third, reducing pollution and hazardous wastes can lower human health impacts to employees while also improving working conditions and labor productivity. Fourth, pollution can adversely impact the health of people, animals, and plants in the community, undermining economic prosperity and quality of life. By looking at ways to reduce pollution and wastes, enterprises often discover opportunities that bring multiple benefits to the enterprise, its employees, and the local community.

BUSINESS COSTS ASSOCIATED WITH POLLUTION AND WASTES

- ✓ Waste disposal costs
- ✓ Pollution discharge fees
- ✓ Waste management and handling costs
- ✓ Pollution control equipment purchase and operations costs (e.g., end of pipe solutions, on-site waste treatment costs)
- ✓ Permitting and regulatory compliance costs (including record keeping and reporting)
- ✓ Insurance costs
- ✓ Worker illness and absenteeism resulting from exposure to pollution, wastes, and/or chemical hazards

Pollution and wastes come in many forms: solid wastes, liquid wastes, air emissions, wastewater discharges, odour, and visibility impairment. Some pollution and waste is non-toxic, while some poses risks and impacts to human health and the environment.

CP typically focuses enterprises on a tiered strategy for addressing pollution and wastes.

- **Reduce.** First, seek opportunities to prevent pollution and wastes from being generated.
- **Reuse.** Second, explore ways to capture and reclaim wastes or pollution for productive use in the process or facility.
- **Recycle.** Third, look for opportunities to collect wastes and pollution in a way that can be sold or given to another enterprise or organization for productive use.
- **Safe and Proper Disposal.** Finally, if it is not feasible to reduce, reuse, or recycle the waste or pollution, ensure that it is disposed of or released in a manner that does not adversely affect human and environmental health.

Questions in the following box help to identify CP improvement opportunities related to preventing and managing pollution and waste.

COMMON POLLUTION AND WASTE PREVENTION OPPORTUNITIES	Y/N?	ACTION TO BE TAKEN
Reduce ✓ Are there ways to eliminate or reduce sources or wastes or pollution?		
Reuse ✓ Can waste materials or chemicals be captured and reintroduced into the process for productive use? ✓ Are there any process steps that can be designed to have "closed loop" aspects that automatically capture and reintroduce inputs using condensation or other techniques? ✓ Can defective product components be refurbished for productive use?		
Recycle ✓ Can you find opportunities to give away or sell any of your wastes? ✓ Are there steps you could take to segregate or improve the quality or purity of wastes that might make them attractive to another enterprise for productive use?		
Safe and Proper Disposal ✓ Are there steps that can be taken to		

better segregate wastes in order to reduce the amount of waste that has toxic or hazardous characteristics and requires special handling and disposal? ✓ Can you install pollution control or treatment systems or equipment that reduces the amount of pollution or its harmful characteristics? ✓ Are there steps you can take to ensure that wastes are properly and safely disposed, or that pollution is released in a manner that minimizes adverse human and environmental health impacts?		

Exercise 3: Identifying target areas for CP

Drawing on your consideration of the questions in the boxes in this chapter, identify the 6-10 most significant resources used by your enterprise (including materials, chemicals, energy, and water). Rank the list by volume purchased and total cost (on a daily, monthly, or annual basis).

Identify the 5 most significant types of waste or pollution generated by your facility. Rank the list by volume generated, perceived level of human or environmental health risk, and total cost to the enterprise (on a daily, monthly, or annual basis).

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3 Engaging people in cleaner production

3.1 Workplace cooperation in cleaner production

People are the key to successful CP implementation. Environmental risks and waste arise throughout an enterprise. Everyone makes decisions or undertakes actions that affect production and material, energy, and water use or waste generation. Therefore, in order to reduce, manage, and eliminate CP wastes and risks – and increase productivity – everyone needs to be involved.

As discussed in Module 1, an important element of effective workplace cooperation is teamwork. Teamwork can be encouraged through setting up an enterprise improvement team (EIT) where management and workers together plan and implement solutions for the problems they want to solve. EITs are a great place to consider cleaner production needs and opportunities. Through EITs, workers can share aspects and areas of work that could benefit from cleaner production actions, and similarly management can gain support from workers for changes, leading to smoother and more effective implementation. In most cases, the best ideas for CP opportunities and solutions will come from those closest to the work or production process.

Since management style affects productivity, managers need to foster a participatory work setting if they want to improve productivity. When employees are involved in problem-solving and other improvement programmes, there is generally higher productivity. This is because solutions are more appropriate (those who are most affected are involved in the process) and workers understand any changes being made to the work environment or machinery because they have been part of the decision making process.

Successful CP involves people at all levels

An initial step in your enterprises' CP journey may be to recognize what environmental gains your enterprise has already accomplished with CP, such as energy savings from turning off lights or machines when not in use. Production managers and workers may not be accustomed to receiving awards or other recognition for environmental improvements, but they will be more likely to seek additional ways to improve once they do. Recognition can be as simple as an announcement in a company newsletter or on a bulletin board. An enterprise can also set up as a competition between production areas and recognize those who achieve the greatest gains with a lunch, for example. Your enterprise may not always succeed with its CP efforts, so that makes it all the more important to recognize and reward successful efforts, to learn from any mistakes, and to continually try new things and work to improve your enterprise's performance.

Exercise 4: Recognizing Past CP Accomplishments

What CP accomplishments has your enterprise made in reducing material use, energy use, water use, waste or pollution?

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Who has been involved in these efforts? How can you recognize their accomplishments?

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3.2 Implementation roles and responsibilities

Since everyone has a part to play in improving productivity, it is important to understand the roles and responsibilities of both workers and managers and to communicate expectations. It is also important to clearly identify who is responsible for managing cleaner production initiatives and activities (e.g., who oversees and organizes CP projects, obtains input from workers, and makes decisions on options) and who is responsible for implementing specific cleaner production actions. Workers need to know what is expected of them in order to effectively do their job.

The next Module in this series, Module 4, goes into more detail regarding job descriptions. Building cleaner production roles and responsibilities into job descriptions is one way to articulate and clarify responsibilities and expectations. Another way is to include specific roles and responsibilities in a cleaner production action plan (discussed at the end of this module).

It is important that senior management at your enterprise show their support for improved Lean and cleaner production initiatives. Management can show support and commitment in several ways:

- Set performance goals, objectives, and targets related to cleaner production

- Provide resources, tools and incentives to enable employees to succeed in making CP improvements
- Invest in training to support CP implementation
- Include cleaner production goals concepts in speeches, newsletters and other communications
- Track cleaner production progress and hold individuals accountable for meeting those objectives
- Recognize cleaner production accomplishments.

3.3 Standard operating procedures

Standard operating procedures (SOPs), introduced in Module 2 and also known as standard work procedures in Lean manufacturing, is an agreed-upon set of work or operating procedures that establish the best and most reliable method of performing a task or operation. The overall goal of SOPs is to maximize performance while minimizing waste in each person's operation and workload. The purpose is to improve consistency in how tasks are performed in order to ensure employee safety and to reduce defects, unnecessary processing, and variability, which in turn result in increased productivity and reduced costs. SOPs are a powerful way to engage all employees in cleaner production.

NO STANDARD PROCEDURES = WASTES + RISK + COSTS

Which of the following situations happen at your enterprise?

- ✓ Machines and lights are left on when not needed
- ✓ Scrap materials are left on the floor
- ✓ Chemicals are not returned to proper storage
- ✓ Wastes and recyclables are not put in the correct bins
- ✓ A process is not operated correctly, producing defective parts
- ✓ Equipment is not properly maintained or operated, causing it to break or affect product quality
- ✓ Tools/parts are not put where they belong, so they are damaged or lost
- ✓ Spills happen frequently
- ✓ Workers do not wear proper protective equipment
- ✓ Chemicals or materials frequently expire or spoil
- ✓ Materials or products are left outside and damaged by weather

All of these situations can be addressed with SOPs.

Improvements in SOPs can be focused on many aspects of production operations including:

- Improvements to the flow of materials
- Improvements in motion
- Establishing rules for operations
- Improvements in equipment
- Separation of people and machines

- Preventing defects

One easy way to begin implementing cleaner production actions is to make sure—if you are developing new SOPs or have current ones that can be amended—that those procedures include all relevant environmental waste and risk considerations. Ideally all SOPs should make very clear to employees the specific steps that are necessary to effectively and safely manage and reduce wastes, pollution, and the use of materials, chemicals, energy, and water.

Consider this example:

Example: metal shavings

An EIT identifies a waste stream coming off a piece of equipment, such as metal shavings coated in oil that automatically get dropped on the floor after a metal piece goes through the machine. Those shavings get disposed of when a worker has some idle time – sometimes a couple times a day, or sometimes not for a few days. The EIT updates the SOP for that piece of equipment and/or the process run by the workers who oversee the equipment to include information on how to properly dispose of the shavings, where and when the shavings should be disposed, and if any protective gear should be worn while handling the shavings. In addition, the EIT could consider adding a receptacle to catch the shavings as they come off the machine, reducing risk and saving clean-up time from having metal shavings lying on the floor. Incorporating this step into the SOP can also reduce unnecessary motion and improve ergonomics by making it so the worker only has to bend half way over to grab the pan an empty it, as opposed to having to sweep the shavings and then bend all the way over multiple times to collect the shavings in a dust pan. The EIT could also modify the SOP to ensure that workers recycle the shavings (if feasible) instead of disposing them.

SOPs are typically conveyed via the following types of documents:

- Regulations – formally established task management methods (job and task regulations)
- Quality Standards – product quality requirements based on production standards specified by customers and adopted as in-house standards for products and inspection procedures
- Specifications – restrictions and other conditions placed on suppliers of equipment and parts
- Technical Standards – detailed standards concerning manufacturing methods and products stipulating dimensions, temperature, etc.
- Process Standards – describe work procedures and processes and usually appear in work procedure sheets or instruction booklets
- Manuals – handbooks used for training and for detailed descriptions of work methods
- Circular Notices – notices that inform people of new or revised standards, necessary preparations or responses, and other related matters

- Memos – common means of communication for prior notification of extraordinary measures, temporary revisions, or other standard-related matters.

SOPs are only useful when they are followed. Three steps help to ensure that this happens:

1. Involve workers in development and review of SOPs.

You may discover that people resist standardization until they understand what it really means and how it benefits the enterprise and employees alike. Sometimes people fear that standard procedures will destroy innovation and creativity. People sometimes may not want to do things the same way as everyone else, and they may not want to do it the same way every time. It seems boring.

But in fact, most enterprises find that once standardization is in effect and standard procedures are in place, creativity, improvement, and job satisfaction increase.

One way to overcome resistance is to actively involve employees in developing and improving SOPs. This will lead to employees "owning" the SOP. Further, those who are closest to the work are often best suited to understand what works and what does not work; they are often likely to have ideas for ways to improve a process or activity. You can also overcome resistance by clearly explaining how a lack of SOPs contributes to costs, productivity losses, and safety or environmental risks.

2. Train employees on SOPs and make them easy to follow.

Developing or updating SOPs to include cleaner production considerations must be followed by ensuring employees are trained on the new procedures. Involve experienced workers who helped develop or update the procedures in conducting the training. Hold training right in the work area (not in a classroom) and give all participants a "hands-on" opportunity to try the new procedure. Be sure to explain why following the procedure is important to the enterprise and the employee's health and safety.

Make it easy for people to follow SOPs. Post easy-to-follow copies of the procedure right in the work area (see Annex 8.1 for an SOP template that includes an example environmental step). In addition, SOPs can be reinforced using tools such as visual controls (e.g., colour coding containers, signs and placards), display of metrics, and use of 5S to make wastes visible; these tools are discussed in more detail later in this module.

In some cases, it may be possible to alter equipment to ensure that standard procedures are followed or to prevent "mistakes" from occurring. In Lean manufacturing this is called "mistake-proofing." For example, it may be possible to prevent spills by installing a valve on a tank that automatically shuts off unless the coupling on a hose is properly engaged.

3. Hold employees accountable for following SOPs and recognize their efforts.

Managers and supervisors should clearly communicate the importance of following SOPs and hold employees accountable for doing so. At the same time, managers should recognize employees for following SOPs and invite ideas for improving SOPs.

SOPs can be a powerful force for improving productivity and implementing cleaner production. Recognition for making improvements builds self-esteem, and skill levels are increased through training. Conditions for boredom and resentment – idle time and overwork – are eliminated. Training become more effective, turnover rate drops, communication among teams and between shifts is increased – people know what they need to know when they need to know it. Only after working in an environment where SOPs are in place do you discover the advantages to each operator that inevitably result.

Exercise 5: Standard operating procedures for cleaner production

Think about common activities at your facility. Are there tasks that create potential environmental wastes and risks? Create a list of existing procedures that should be modified to better include clean production opportunities. Create a list of new procedures that are needed to fill gaps where SOPs don't exist for common activities that affect resource use and waste and pollution generation.

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4 Initial assessment and measuring performance

4.1 Facility walk-through and eco-mapping

Conducting a walkthrough

A facility walkthrough or "waste walk," as it is commonly referred to in Lean practices, is one of the most effective techniques for identifying potential environmental wastes and risks at an enterprise, and should be one of the first steps in implementing CP. During a facility walkthrough, management and/or

workers walk through the different areas of the facility and record environmental wastes and risks they observe such as leaks of steam, water, or fuel oil; excessive machine idling; or poor storage of chemicals. Your answers to the questions and exercises in Chapter 2 of this Module can be used as a guide for what you should be looking for in a facility walkthrough.

In addition to noting inefficiencies in equipment, pollution streams, and potential worker safety hazards, those conducting the walkthrough should take notes on workers' views on existing operating conditions and parameters. Oftentimes those who are most familiar with a particular piece of equipment or task will have valuable insight on potential risks and hazards that may not be immediately apparent to someone conducting a walkthrough. Similarly, workers' familiarity with certain operations may lead them to suggest innovative and thoughtful solutions to identified problems.

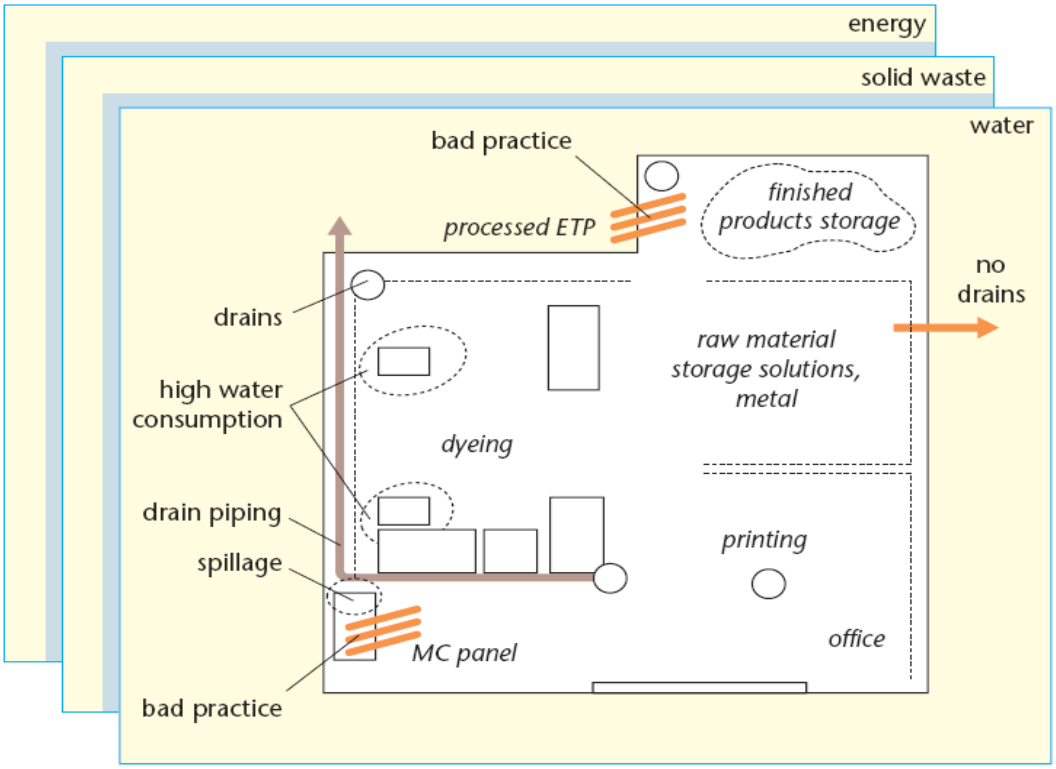
Walkthroughs are an easy way to gather an initial assessment of resource wastes and risks at an enterprise. However, to be truly effective, walkthroughs should be conducted more than once as part of ongoing continuous improvement cycle. Future walkthroughs will help to identify progress from actions implemented, as well as identify new problems and opportunities that may have been missed or did not arise until after a walkthrough was completed.

Eco-mapping

Eco-mapping is a simple and practical tool providing visual representation of areas of concern and can be used in conjunction with a facility walkthrough. Eco-maps can be developed for an entire facility or for a particular work area. In order to keep the maps simple and understandable, generally separate maps are developed for specific themes or process inputs including:

- Water consumption and wastewater discharge
- Energy use
- Solid waste generation
- Odours, noise, and dust
- Worker safety and health risks.

Each eco-map should include everything related to the particular problem being studied. For instance, an eco-map for water consumption and wastewater discharge must pinpoint the location of overflows, spills, leaks, excessive use of water, etc. Areas should be highlighted using colour codes or distinct symbols to distinguish between areas that should be monitored and areas where problems need to be dealt with as soon as possible. In the example below – a sample eco-map for water in the printing section of a textile company – areas that should be monitored are encircled by dashed lines and problems that need to be dealt with immediately are indicated by orange hatched lines.



The next step in eco-mapping is to think about facility layout in terms of cleaner production opportunities. For example, are there ways to reduce transportation needs within your facility (e.g., forklift trips)? Arranging equipment and workstations in a manner that improves the flow of product and process inputs can significantly reduce the amount of energy required to support a production process.

Exercise 6: Mental facility walkthrough and eco-map

Draw a general layout of what you think your factory floor or a specific work area in your facility looks like. Mark on the map areas of potential environmental waste and risks that could benefit from cleaner production actions. Draw on the information you identified in the boxes and exercises in Chapter 2.

(Note: This exercise should be followed-up on by conducting an on-site walkthrough at your facility. Often people are surprised at the difference between what they think is happening and what is really happening on the facility floor.)

4.2 Metrics

Using metrics in CP efforts will allow your enterprise to document the environmental and associated cost benefits that are part of CP implementation, as well as identify targets for future improvement efforts. One simple way to incorporate environmental metrics into your enterprise's activities is to add one or more environmental metrics to the list of company performance indicators, discussed in Module 1. Types of environmental metrics include:

- Scrap/Non-product Output
- Materials Use
- Hazardous Materials Use
- Energy Use
- Water Use
- Air Emissions
- Solid Waste
- Hazardous Waste
- Water Pollution/Wastewater

In addition to environmental metrics, where possible, measure the costs associated with waste generation and disposal. Measuring costs makes it easier to communicate with mangers and company decision-makers about the business impacts and overall costs to an enterprise associated with inefficient resource use or waste generation. This in turn makes it easier to implement CP actions that result in less waste, greater productivity, and oftentimes increased savings. Below is a more comprehensive list of basic metrics to consider tracking.

Category	Definition	Metric	Unit of Measure
Input Measures			
Energy Use	Any source providing usable power such gas, coal, fuel oil, etc., or consuming electricity Transportation and non-transportation sources	Energy used, total cost of energy used	Specific to energy source such as BTUs or Kilowatt hours, % reduction, energy use and cost/unit of product
Land Use	Land covered by buildings, parking lots, and other impervious surfaces Land/habitat conservation	Land converted, land restored or protected, area of impervious surfaces	Square feet, acres, square metre
Materials Use	Materials used (total or specific), ex. packaging materials Proportion of input materials that were reduced, recycled or recovered (vs. virgin materials)	Materials used, percent utilization of materials, post-consumer recycled content, cost of unused materials	Pounds, Tons/year, pounds, Tons/unit of product, % materials utilization
Toxic/ Hazardous Chemicals Use	Use of hazardous and toxic chemicals that are regulated or are otherwise of concern	Toxic/hazardous chemicals used	Pounds, Litres/year, pounds, Litres/unit of product, % reduction, cost savings/ % reduced
Water Use	Incoming raw water, from outside sources, e.g., from municipal water supply or wells, for operations, facility use, and grounds maintenance	Volume of water used, P2 to reduce priority chemicals/quality standards/pre-treat standards, total cost of water used/saved	Gallons, cubic metres/year, % reduction, % recycled Pounds, Cubic metres/ Priority Chemicals/year, % reduced, % recycled, cost per Gallon/cubic metre
Non-Product Output Measures			
Air Emissions	The release of any of the following: • Air toxics • Carbon Monoxide	Air emissions generated	Pounds, Tons/year, % reduction

	• Lead
	• Ozone and its precursors, including:
	  ○ VOCs (volatile organic compounds)
	  ○ NOx (nitrogen oxides)
	• Ozone-depleting substances
	• PM10 (particulate matter)
	• PM2.5 (fine particulate matter)
	• Sulfur Dioxide
	• Greenhouse gases, including Carbon Dioxide		

Water Pollution	Quantity of pollutant in wastewater that is discharged to water source. May include: • Heavy Metals - Cu, Pb, Hexavalent Chromium, Cadmium, Zn, Ni, Hg, • Organic Pollutants and Pesticides, Conventional pollutants, e.g., oil and grease, BOD, TOC and suspended solids, and • Nutrients - N, P • Pathogens • Sediment from runoff • Wastewater discharge volume	Mass or concentration of pollutants discharged, cost of wastewater treatment	Pounds, Kilograms /year, Milligrams/Litre or % reduction
Solid Waste	Wastes (liquid or solid) other than hazardous wastes	Solid (non-hazardous) waste generated, disposal costs	Gallons, Cubic metres/ or pounds, Tons/year, % reduction, % recycled

Tracking inputs and outputs over time and comparing them to production levels can help to identify problems and concerns (e.g., if there is a spike in a water or electric bill), as well as to assess progress in addressing indentified problems over time. Metrics can be useful at the facility level and in specific-process areas. For example, chemical use and hazardous waste generation may be important to measure for one process, while water use may be most important to measure for another process.

Here are some useful tips for identifying and tracking metrics:

- **Do not waste time trying to track everything**. Most enterprises have a lot of potential environmental metrics that could be tracked. Focus on measuring things that are most important or would have the greatest impact regarding costs, risks, or opportunities.

- **Start by collecting available information.** This includes process flow diagrams, plant layouts, inventory and dispatch data sheets, raw material consumption and cost data, production data, production log sheets, material balance, water balance and conservation details, energy consumption details, emissions records, waste analysis records, waste generation and disposal records, maintenance log sheets, and other relevant data.

- **Share metrics visibly**. Providing information on performance around metrics can raise employee attention and enable improvement. It also provides a platform for setting targets and developing challenges between different areas (e.g. which part of the facility can reduce their energy the most).

- **Consider translating metrics into costs.** (E.g., energy saved per produced unit or year). Make the metrics easy to understand and tangible to everyone.

Exercise 7: Environmental metric data

Identify the key sources of information where you would obtain the data for environmental performance metrics at your facility (e.g. utility bills, water bills, purchasing records).

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Now draft a table or spreadsheet where you could input this information to track changes over time.

5 Linking Lean and Cleaner Production methods

The initial assessment phase covered in the previous chapter provides comprehensive information about the processes at an enterprise. Good housekeeping gaps, and organizational or other obvious problems, i.e., those indicated during a walk-through or on an eco-map, can usually be tackled without any further detailed assessment. This chapter contains a collection of methods (several drawing from Lean manufacturing methods) for getting started with implementing CP and addressing the problems identified. Many of these options generally require minimal investments of time and money. These tools provide logical and methodical approaches that make it possible to solve waste and emission problems at the source, improve productivity, and ensure continuity of CP activities.

5.1 5S as applicable to cleaner production opportunities

5S, as introduced in Module 1, is a method used to create and maintain a clean and orderly work environment. 5S is well aligned with CP in that it helps to clean up the workplace, get rid of unnecessary materials and wastes, makes wastes visible, and reduces risks to worker health and safety. 5S also helps to reduce costs, increase productivity, and foster a culture of continual improvement and employee engagement that is essential for successful implementation of CP.

Before and after: 5S applied to a storage cabinet

Incorporating CP considerations into already established 5S checklists and implementation is straightforward. Following is a sample list of questions that could be added to a 5S checklist to incorporate CP considerations.

5S QUESTIONS FOR ELIMINATING ENVIRONMENTAL WASTE AND RISK

Sort (Get rid of it)

- ✓ Are potentially risky items and environmental wastes appropriately marked?
- ✓ Are all marked items being disposed of properly, including those that must be managed as hazardous wastes?

Set in Order (Organize)

- ✓ Are material containers clean, stored off the floor, closed, properly stacked,

and stored/staged in the proper areas?

- ✓ Are all containers with chemicals or wastes covered or sealed when not in use?
- ✓ Are all containers with materials, chemicals, and/or wastes properly labeled?
- ✓ Are initial accumulation points for hazardous waste clean and organized, and do they have effective visual controls?

Shine (Clean and solve)

- ✓ Are any leaks evident from equipment, piping, tanks, exhaust lines, or other areas in the workplace?
- ✓ Is air quality in the work area good and free of dust, odors, and fumes? Is air flow in the area good? Are ventilation systems clean and unobstructed?
- ✓ Are all drains in good condition, free flowing, and unobstructed? Are all drains properly labeled to ensure that only acceptable substances are disposed down them?
- ✓ Are exterior locations near storm water drains and storm water retention areas free from garbage and debris that can cause obstruction?
- ✓ Are garbage and recyclables collected and sorted correctly? Are recycling containers and bins free from extraneous materials?

Standardize (Get consistent)

- ✓ Are SOPs documented and available for the area?
- ✓ Are environment, health, and safety management activities and procedures relevant to the work area integrated into SOPs?

Sustain (Keep it up)

- ✓ Are SOPs being followed?
- ✓ Are workers in the area aware of chemical hazards associated with SOPs?

Exercise 8: 5S and CP at your facility

What are five cleaner production items you could add to your 5S checklist?

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5.2 Visual controls

Visual controls are used to reinforce standard operating procedures and to display the status of an activity so every employee can see it and take appropriate action. Visual controls standardize best practices for energy and equipment use, and can be adopted facility wide. Visual controls make environmental wastes and risks visible and as easy as possible to eliminate by giving people prompts and reminders about actions to take. Visual controls also provide a powerful way to track actual results against targets and goals, and encourage additional improvement.

These easy-to-use cues can be as simple as the following common techniques:

Paint lines to clearly indicate where something belongs on the floor or wall.

Use color coding to make it easy to quickly identify where things belong (e.g., separating wastes from recycling) or to help employees quickly identify and report key information (e.g., color-coded pipes for reporting leaks).

Use signs or placards to concisely communicate at point of action (e.g., turn out the lights or unplug equipment that is not in use).

Use approaches that signal the status of something (e.g., use a clear container to see how much material is left or install a light that indicates if equipment is on or off).

Clearly label storage bins, chemicals, waste receptacles, and other items to eliminate confusion and mistakes about what goes where.

5.3 Right-sizing equipment and containers

CP benefits are often realized as a result of using right-sized equipment and containers to meet production needs. The concept of right-sizing is based on the idea in order to get work done, you may not need to have as big of equipment or as much materials as you currently use. Right-sizing equipment and material to better fit production needs can save money, reduce energy and water use, and produce less waste.

Right-sized equipment

Right-sized equipment is designed to meet the specific needs of an individual process step, rather than the processing needs for an entire facility. Conventional manufacturing equipment is often over-sized to accommodate the maximum anticipated demand. Since purchasing a new large piece of equipment is often costly and time-consuming, engineers often design in additional buffer capacity to be sure that the equipment does not bottleneck production. Conventional, oversized equipment can lead a company to use significantly more resources than needed to get the job done.

Since right-sized equipment is geared toward a specific end use and production capacity, it often is much more energy efficient than conventional, large equipment. For example, the natural gas or electricity needed to fire a large dryer oven is typically the same whether the line is being run at capacity or if only a few parts are being processed. Shifting to a smaller piece of equipment designed for the number of parts that are usually processed at one time can save a large amount of electricity.

In addition, right-sized equipment typically requires only a fraction of the chemical inputs of conventional equipment. For example, a facility with one large, 1000-gallon part cleaning and degreasing tank may only wash a few small parts in each batch. A shift to much smaller, 10-gallon, right-sized parts cleaning tanks may be

all that is needed to get the actual work done, saving hundreds of gallons of chemicals.

Right-sized Containers

Right-sized containers are typically associated with "unit of use ordering," which involves purchasing chemicals in quantities that are appropriate for a particular task or work area. Buying large volumes of chemicals in bulk, for instance, can be cheaper in the purchasing phase; however this often results in a batch of chemicals that expires or become unusable due to contamination or spoilage. When that happens, the enterprise incurs an additional cost to dispose of the unused or no longer usable materials. In this case, the enterprise would have been better off paying a little more upfront for a smaller amount of chemicals (i.e., the right-sized container) that was closer to the actual production needs, saving money and reducing hazardous waste in long run.

Example right-sized containers

Right-sized containers, which are often reusable, can also be used to limit the need to transfer materials from larger cribs or containers into smaller ones, reducing potential for spills. A potential environmental trade off with right-sized containers, however, is that there can be additional packaging waste. In some cases, it may be useful to consider purchasing chemicals in bulk to eliminate excessive packaging, especially if the packaging is considered hazardous wastes, or to look for alternative solutions to eliminate the wastes.

If buying a smaller quantity of materials is not feasible, another Lean concept, known as kitting, can be used. Kitting is a technique that involves the gathering of all the parts and materials needed for a particular manufacturing or process step and issuing the 'kit' at the right time and in the right quantity. Kitting can prevent the excess use of materials or over-mixing of chemicals by only providing materials in the amount needed to do the job. For example, kitting of chemical adhesives can improve the consistency of the amount and quality of adhesives used, while eliminating the need to dispose extra adhesives as hazardous waste.

5.4 Total productive maintenance

Total productive maintenance (TPM) is a Lean method that focuses on optimizing the effectiveness of manufacturing equipment. TPM builds upon established equipment-management approaches and focuses on team-based maintenance that involves employees at every level and function. TPM can prevent productivity losses by maintaining equipment.

Increased equipment operating efficiency reduces energy waste. When machines are optimally tuned to accomplish the desired work, energy inputs are most efficient. TPM's emphasis on equipment efficiency can lead to reduced costs, increased productivity, and fewer defects. TPM focuses on **six big losses that lead to equipment inefficiency:**

1. Breakdowns
2. Reduced speed

3. Setup and adjustment loss
4. Defects and rework
5. Idling and minor stoppages
6. Start and yield loss

Eradicating the six big losses maximizes the productivity of equipment throughout its lifetime. With proper equipment and systems maintenance, facilities can reduce manufacturing process defects and save in energy costs. Consider using one or more of the following strategies for integrating TPM efforts into CP activities to improve energy and equipment efficiency at your facility.

STRATEGIES FOR INTEGRATING CP INTO TPM ACTIVITIES

- ✓ Integrate CP opportunities, such as energy reduction, into autonomous maintenance activities (performed by the machine operator)
- ✓ Update SOPs to check for and report defects, idling, or other equipment inefficiencies
- ✓ Train employees on how to identify energy and resource wastes and how to increase equipment efficiency through maintenance and operations
- ✓ Use visual controls, such as a laminated "cheat sheet," to help workers quickly and easily identify equipment problems

Case Study: Equipment maintenance and management

Vinadataxa is a state-owned printing company based in the outskirts of Hanoi that acts as a printer as well as a paper trading company supplying other printing companies in Vietnam. The factory prints newspapers, magazines, books, calendars and other items. Because of newspaper printing, two shifts per day are required. The factory was only operating at around 60% capacity. There was no measure for tracking production progress and discipline was weak on checking working progress due to the low production levels and low capacity utilisation. There was a need to reduce processing time and reduce the number of machines that are either underutilised or not used at all. There seemed to be a view that, since the machines were not working all the time then there was little requirement to service them. However, this kind of intermittent servicing actually achieves little benefit for the good running of the machines, but can and does add to the problem of defects which then had an impact on outputs and the achievement of productivity targets - which the company had consistently been missing.

Printing company equiptment

Actions taken by the factory

The Factory Improvement Team, composed of workers and management, assessed the systems that were in operation, together with the layout of equipment and their constituent parts. The team then implemented a relatively dramatic programme of change that has had a positive impact on quality, productivity and the working environment. The company implemented a cleaner production programme and

established a fume extraction system to remove hazardous gases resulting from the production processes. They are now extracted in an environmentally sensitive manner so that workers are no longer exposed to hazards.

They asked the suppliers of all the new equipment installed during the last two years to translate the technical documents into Vietnamese so that the workers can understand, allowing a maintenance programme to be more easily implemented. With regard to the older equipment, the factory made its own arrangements to have all the technical documentation translated into Vietnamese. A clear programme of planned maintenance has been developed and implemented. The plan details very specifically all the actions to be taken on a daily, weekly and monthly basis. One machine running at high temperatures is an air compressor that not only generates heat, impacting on air temperature control in the workshop, but also noise. This equipment has been moved outside the workshop. This reduced air-conditioning requirements and the noise pollution no longer affects the workers.

Impact of changes
The impacts of the changes that the company implemented are clear in terms of the improvements to the working environment; reducing workers exposure to hazardous gases, reducing noise pollution, and developing a better understanding of equipment and how to use it and maintain it. The company is experiencing rapid growth – output for 2007 was double that of 2006. This is being achieved through a greater level of commercial activity while employing fewer staff. They are also being asked to bid for more competitive contracts which they are winning and delivering more effectively. The start date for a recent contract was delayed by weeks, yet the company managed to deliver 1.6 million books to the original deadline.

Exercise 9: Implementing CP methods at your facility

Identify specific opportunities to implement CP actions at your facility using the following methods:

Visual controls

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Right-sized equipment and containers

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Total productive maintenance

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6 Going further with CP

6.1 Analytical tools to identify improvement projects

Once an environmental waste or risk problem is identified, it can be useful to dig deeper to understand the root cause of the problem. Furthermore, an EIT may decide to focus concerted attention on a particular process area if there is a significant opportunity to improve efficiency or reduce wastes, pollution, or risks in that area. More detailed analysis can uncover multiple sources of specific wastes in a single process, which can lead to new waste and risk-reduction opportunities. The following are examples of tools that exist to gather data on specific CP problems and analyze existing processes and opportunities at a more detailed level.

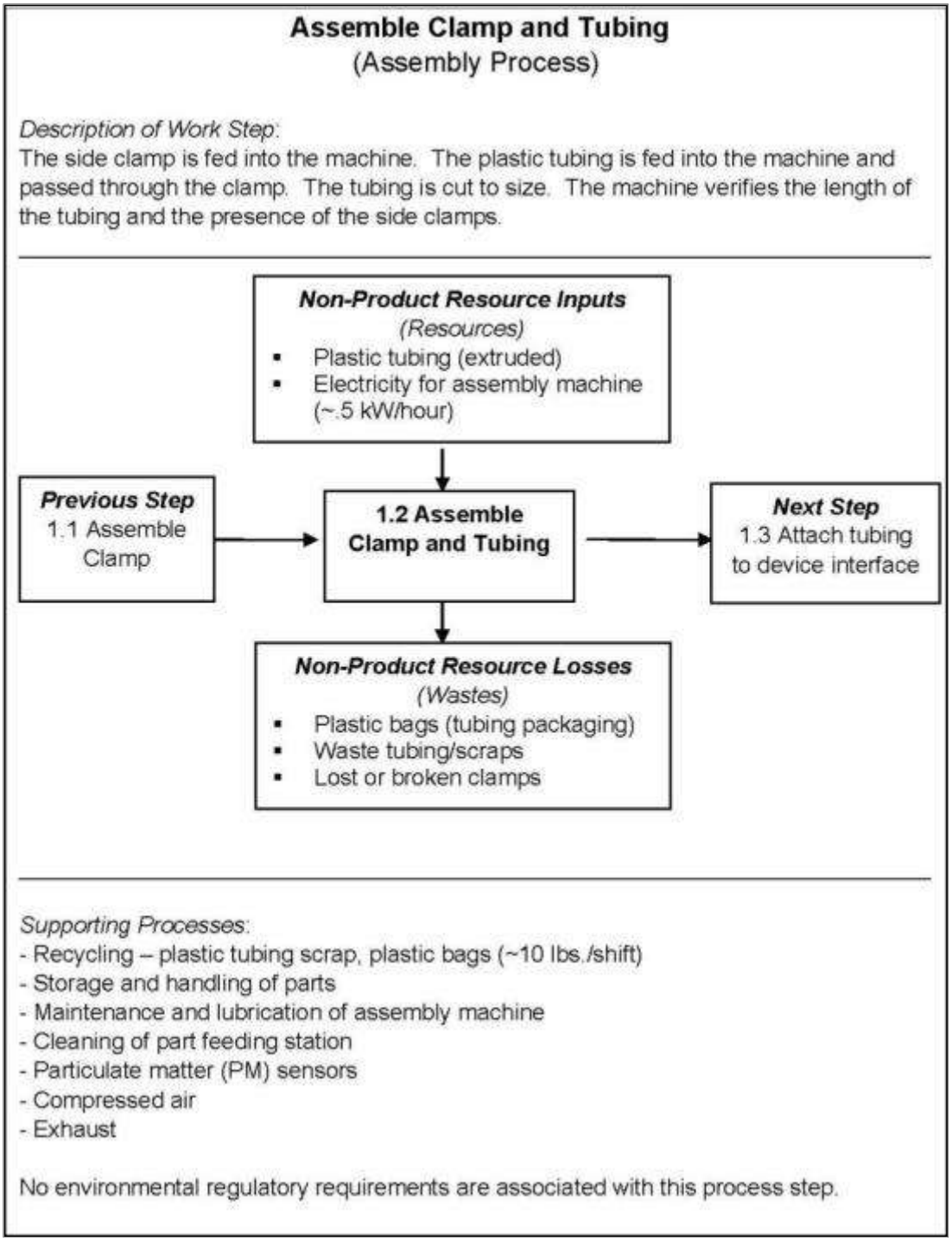
Process mapping

Process mapping is a tool that creates a simple workflow diagram to bring forth a clearer understanding of steps within a specific production process. Like eco-mapping it generates a graphical illustration for easy access to information. Process maps are a collection of individual blocks, which, when combined, depict the various steps that comprise an overall process as well as the functional dependency between those steps. Thus by using available information and direct observation, the sequence of steps (or individual process blocks) can be mapped as a single process flow diagram. An example of a single process block (step 1.2 in the process) is shown below.

Understanding exactly how a process works is critical in preventing inefficiencies and reducing all forms of waste. Often the exact nature of relationships between the individual steps within a process is not clearly understood. A process map identifies all the crucial elements of a process and clearly shows the sequence and relationships between the individual steps. This tool helps to better understand a process and how it uses resources, to find the root causes of environmental wastes and risks, and to identify opportunities for CP actions to address the issue areas.

Process maps are used to record information on:

- Resource inputs (materials, energy, and water) and non-product outputs such as pollution and scrap for each process step
- Resource and cost accounting data
- Regulatory issues and requirements.



The main steps involved in generating a process map are:

1. Identify the main sequential, high-level steps involved in the production process. Try to keep the steps to six or less.
2. For each step, identify what the inputs to the step are - both direct material and product part inputs, as well as supporting resource inputs (e.g., heat, electricity, fuel, water).
3. For each step, identify the outputs - both product/product parts and non-product output (e.g., scrap, waste, wastewater, ambient heat, air emissions).

4. Identify data sources needed to pinpoint the size/amount of the input and output flows.
5. When finished, allow the on-site workers (if they were not already involved in developing the process map) to review the findings. This will ensure accuracy for each step. It is important to note that developing a process map requires the input from a number of personnel.

Following the steps above to develop a process map then allows you to answer the questions:

- Are there variations in the material inputs and waste outputs that do not correspond with the product output levels?
- Are there big waste streams (non-product output streams) coming off the process that should be targeted?

Generating a process map can be of great benefit as it concentrates the mind on the process and can often lead to the identification of obvious process optimization and CP opportunities. These "easy fixes" or "low hanging fruits" often require no further investigation or investment and can be implemented instantly.

Exercise 10: Understanding processes – "The Honest Abe Case Example"

Review the following information and then answer the questions below.

The "Honest Abe" is a traditional country-style restaurant in the center of Chicago. Since 1876, guests have come from near and far to enjoy the famous mashed potatoes served at the Honest Abe. Let's take a look inside the kitchen and observe how the mashed potatoes are "produced."

First, the raw, gritty potatoes are washed and peeled. Old Joe, who helps out in the kitchen, is responsible for peeling the potatoes, and this is how he spends most of his working hours. After so many years of this tedious task, he's not exactly thrilled by the job. The peels are thrown in a large trashcan, along with the other garbage from the kitchen. Nellie, the ancient cleaning lady, empties the trash into the dumpster out back at the end of each day. The peeled potatoes are cooked in a large pot that is always filled to the brim with water. This makes it easier for the cook to measure the salt: 2 heaping teaspoons of salt in every full pot. There are two old electric ranges in the kitchen, upon which two pots full of water are constantly boiling. The cook claims it's faster to cook the potatoes like this, especially since orders are continuously streaming into the kitchen. It wouldn't make sense to keep turning the stove on and off. The potatoes have to be cooked for exactly 20 minutes. The cooking water is poured down the drain, and Joe lets the potatoes cool down enough for him to mash them. It takes a little while for the waiter to pick up the finished potatoes. And at lunchtime, the restaurant is so full that he barely has time to serve everyone. Sometimes ("hardly ever," according to the waiter), the potatoes arrive at the table so cold that the customer refuses to eat them and sends them back. That doesn't really bother the waiter, who has worked here for ages. Nellie is ready at the sink to clean the plate, toss the potatoes and

sing a song about the good old days.

1. What is the end product desired by the customer?
2. What material, energy and water inputs are required in the production process?
3. Which of these inputs are not components of the desired end product (e.g. Non-Product Outputs - NPOs)?
4. Who participates, either directly or indirectly, in creating these NPO's?
5. Which information would be necessary to quantify the NPO streams?
6. What are the costs generated by the NPO's?
7. What are the possible environmental effects of the NPO's?
8. What are the causes for the creation of the NPO's?
9. What measures could help to reduce the NPO streams?

5 Whys Approach

The approach of asking "why" five times is used to explore the cause and effect relationships underlying a particular problem or defect. Asking "why" five times is a useful strategy for identifying the root causes of wastes and risks, making it easier to reduce or eliminate the problem. This approach often reveals simple solutions to eliminate wastes, save time, cut costs, and improve the quality of a process. Following is example of how the five whys technique can identify causes of chemical wastes.

ASKING WHY FIVE TIMES

- *Why is the solvent a waste?* Because the solvent is contaminated with oil.
- *Why is it contaminated with oil?* Because the solvent was used to clean oil off the parts.
- *Why are the parts oily?* Because the manufacturer puts a coating of oil on them before shipping them to this facility.
- *Why does the manufacturer put a coating on them?* To prevent the parts from corroding after manufacture.
- *Why is this type of corrosion protection absolutely necessary?* We don't know any other ways to protect the parts from corrosion. Let's form a team to identify and test some alternatives.

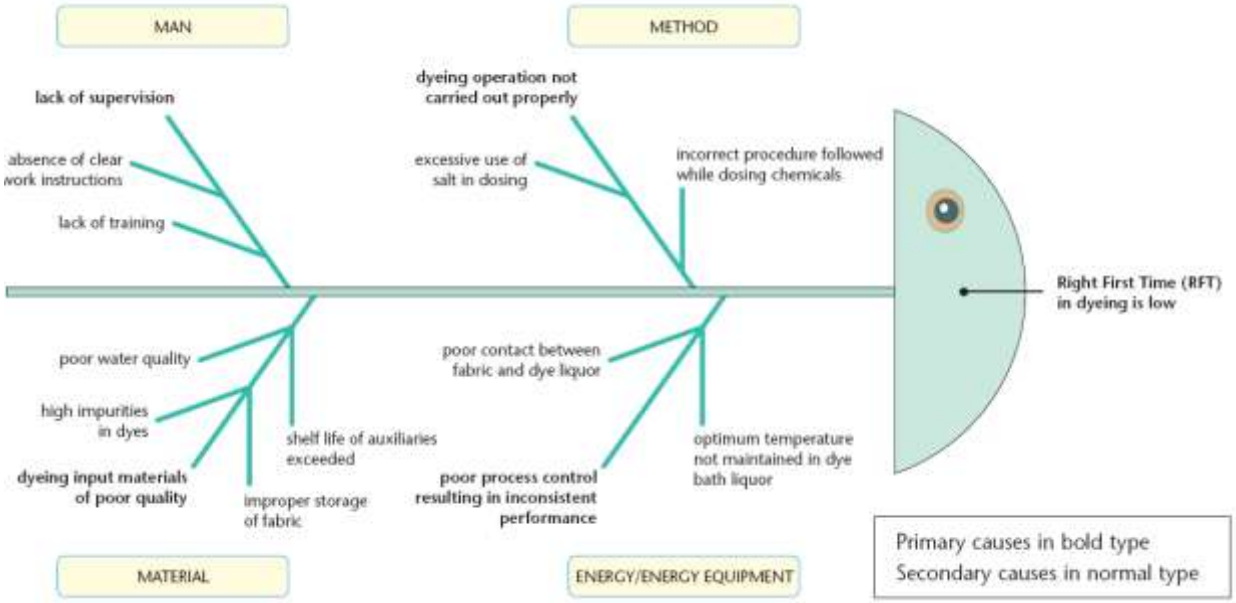
In this example, the root cause of solvent waste is corrosion protection. There may be other ways to achieve that objective without using oil.

Source: Arizona Department of Environmental Quality, Pollution Prevention Analysis and Plan Guidance Manual, March 2006, www.azdeq.gov/environ/waste/p2/download/first.pdf.

Fishbone diagram

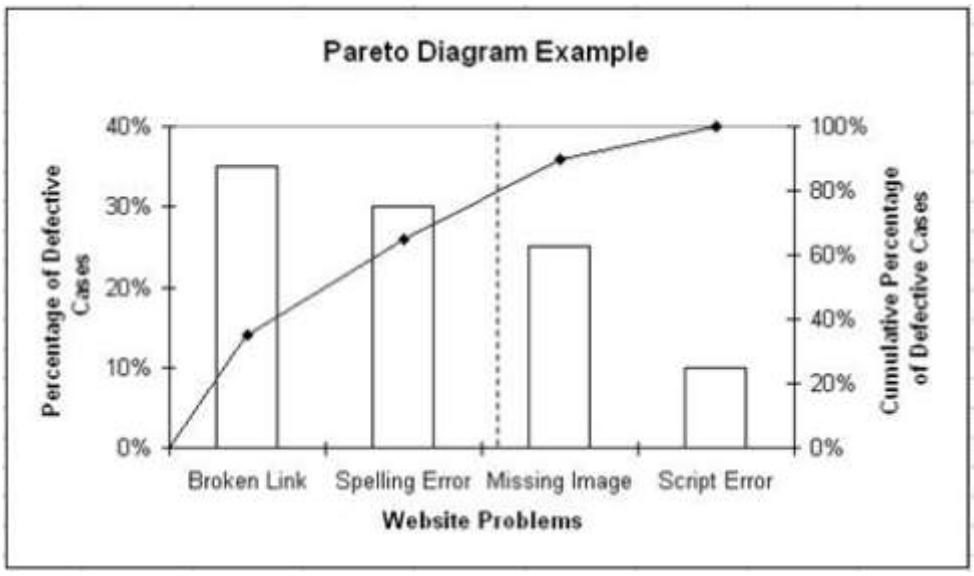
A fishbone or cause-and-effect diagram is a useful technique that is used to trigger ideas and promote a balanced approach in group brainstorming sessions where individuals list the causes and effects of problems. This tool was introduced in

Module 2, and can be applied to CP actions. The fishbone diagram is an excellent tool for cause diagnosis in complex situations in which a number of factors are involved. Once the diagram has been prepared, and EIT can use it to help generate improvement options. Below is an example diagram looking at a winch used in a textile dyeing process. In this example, primary causes of defects or inefficiencies are listed on the main "fish bones" (e.g. input materials of poor quality) and secondary cases are listed on the secondary "fish bones" (e.g. poor water quality).



Pareto Charts

Pareto Charts weigh each type of defect according to severity, cost of repair, and other factors in order to determine which types of defects occur most frequently. The Pareto Chart is a bar graph arranged in descending order of size of importance from left to right. This information facilitates prioritization of response actions. Pareto analysis separates the most important causes of a problem from trivial causes, and thereby highlights the most important problems on which to concentrate.



Source: http://www.projectsmart.co.uk/pareto-analysis-step-by-step.html

Exercise 11: CP problem assessment

Choose an environmental waste or risk problem area that you know exists or likely exists at your facility (it can be a problem you identified in a previous exercise such as the mental facility walk-through or in Chapter 2) and use one of the tools described above (5 whys, fishbone diagram, or process mapping) to identify the root cause of the problem. Does this help to identify any solutions?

6.2 Analysing improvement options

After identifying and assessing problems within a process, the next step is to identify and evaluate a range of potential solutions to the problem or ways to improve the process. You will then need to assess the various options based on a set of criteria to determine which option to implement. Here is a list of example criteria used for analyzing CP solutions:

- Ease and feasibility of implementation
- Timeline for implementation
- Costs
- Impacts on the broader production process and product quality
- Effectiveness at solving a problem.

It is important to brainstorm a wide range of potential options. The best way to do this effectively is to involve all levels of management and staff at the enterprise. Involving everyone in this activity will help to develop a sense of ownership of the options generated and to gain insight into why a particular option is recommended for implementation. Some companies use the "rule of 7," meaning options will not be considered until there are at least seven options identified. This forces creativity which can be useful as the cheapest and best option may not always be immediately obvious.

Improvement options may fall into one of the following categories (this is an individual categorization; you may change it to the needs of the client / company):

- **Housekeeping:** improvements to work practices and methods, proper maintenance of equipment, etc., come into this category. Good housekeeping can provide significant benefits in terms of resource savings. These options are typically low cost and provide low to moderate benefits.
- **Management and personnel practices:** management and personnel practices include employee training, enhancing operator skills, and the provision of incentives and bonuses to encourage employees to strive conscientiously to reduce material and energy wastes and emissions. These options are typically low cost; they can provide moderate to high benefits.
- **Process optimization:** involves rationalization of the process sequences, combining or modifying process operations to save on material and energy resources and time, and improving process efficiency. For instance, some washing operations may be made unnecessary by changes in raw materials or product specifications.
- **New technology:** often more resource-efficient and help in reducing energy and material wastes, as well as increasing output or productivity. These options are often capital intensive but can lead to potentially high benefits. Modifications in equipment design may be another option. They tend to be less capital intensive and can lead to potentially high benefits.
- **Raw material substitution:** there may be better options for primary and auxiliary raw materials in terms of cost, process efficiency, or reduced health and safety related hazards, and these options can be substituted for the current materials. Where energy is concerned, it may be useful to evaluate the applicability and the possibility of cleaner/renewable sources.

- **New product design:** changing product design can have impacts on both the 'upstream' and 'downstream' sides of the product life cycle. For example, redesigning a product may reduce the quantity or toxicity of materials in the product, reduce the use of energy, water and other materials consumed during the product's use, reduce packaging requirements, or increase the 'recyclability' of used components.
- **Recovery of useful by-products, materials and energy:** entails recovery of wastes (in the form of by-products from the process or from resources), which may have useful applications within the industry itself or outside of it. As the wastes or by-products are produced anyway, this type of option can generate additional revenue with little or no extra effort.
- **On-site recycling and reuse:** on-site recycling and reuse involves returning of waste energy or material to the original process, or using these as inputs to another process. Remember, though, that it is better not to generate waste in the first place, rather than to generate it and then recycle, recover or reuse it.

In some cases where larger systemic changes or significant capital investments are involved, more detailed analysis of improvement options may be needed. The extent to which you may need to conduct more detailed assessment depends largely on the magnitude of the costs (the extent to which capital investment would be required) and complexity of the problem and its potential solutions. In these instances, there may be external technical assistance available to help with the analysis. Many countries and sectors offer this type of assistance. Similarly, often big international companies will offer technical assistance to smaller companies that are part of its supply chain.

To find out information on pursuing more detailed assessments, contact
the UNIDO Cleaner and Sustainable Production Unit
(http://www.unido.org/index.php?id=o4460)
or National Cleaner Production Centre
(http://www.unido.org/index.php?id=o5133).

6.3 Considering financial factors in option prioritization and selection

The assessment and analysis described above help to eliminate options that are not viable. The remaining options need to be prioritized and one or more selected for implementation. In most cases, the analyses will indicate that different options have different advantages and disadvantages with regard to the criteria used in the evaluation (e.g., impacts on productivity or product quality, technical feasibility, financial and economic viability, environmental performance, and health and safety benefits). For options that require capital investment (e.g., purchasing equipment), the enterprise may have specific financial analysis requirements (e.g., calculation of return on investment) or application procedures that are required to determine if the project should be funded.

When considering financial and economic aspects of a CP option, it is important to consider both the initial "investment" costs of implementing the option as well as

operational costs and savings. Investment costs may include the cost of purchasing equipment and the cost of labour to install the equipment or make the change. Common operational costs and savings (or benefits) related to changes in on-going training and labour costs, resource costs (e.g., material, water, and energy), waste costs, and the value of production throughput. Enterprises use information on costs and savings/benefits to consider the value of individual projects and to compare options. Two common financial analysis methods, which utilize information on costs and savings/benefits, are described below.

- **Payback period**. Payback period refers to the period of time required for the return on an investment to "repay" the sum of the original investment. Payback is often used because it is easy to apply and understand. It is important to note that payback is a simplistic calculation that does not account for important considerations such as the time value of money, opportunity cost, risk, or financing.

- **Return on investment (ROI)**. ROI is the ratio of value gained or lost on an investment relative to the amount invested. ROI is usually expressed as a percentage. Enterprises compare the rates of return of different projects to select which projects to pursue in order to generate maximum return. ROI, also known as the rate of return, enables users to consider opportunity costs – ways in which the enterprise's limited investment capital can be best used to create value for the organization. For more investment intensive CP options, an enterprise should use ROI.

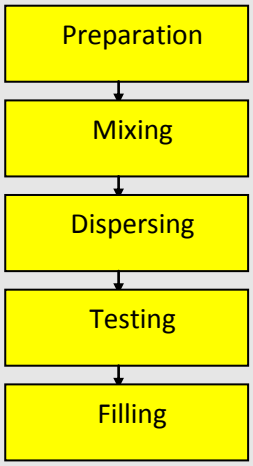
An option should only be selected for implementation if the enterprise is willing to commit the necessary financial and management support that is needed for effective implementation.

Case Study: Assessing CP Options in a Paint Manufacturing Company

A paint manufacturer in Amman, Jordan makes coatings for decorative, industrial, automotive and marine applications. The company conducted a "cleaner production assessment" to identify and evaluation a range of options to reduce costs, improve quality, and reduce environmental impacts. The assessment focused on production of the emulsion and oil-based paints.

Mixing Paint Ingredients

Process Flow Diagram



The major steps for the production process include: preparation of raw materials, mixing, dispersing, testing and filling of the product. The major raw materials used are solvents (water and chemicals), pigments, powder, binder, resin and additives. The main source of the energy is the electricity (the company consumed 478,440 KWh in 2003). Waste solvents and wastewater resulting from the cleaning of mixers and containers are the main wastes generated from the company in addition to dust and solvent emissions.

23 CP options were identified to be feasible for the company. The four options are described below. Economics savings are measured in Jordanian dinars (JD).

Option	Environmental Benefits	Economic Savings		
		Savings (JD/yr)	**Investment** (JD)	**Payback**
Option 1- Adding ammonia By adding ammonia after the dispersing step and not in the first step, the viscosity of the solution will be reduced and this will reduce the energy consumption.	18,000 KWh/yr	700	None	Immediate
Option 2- Install pressure safety valve The installation of pressure safety valve between mixing tank and xylene storage tank will reduce solvent losses.	3480 litres of solvent/yr	870	440	0.5 yr
Option 3– Install timer The option of installing timer to switch off the mixer while waiting samples results from the QC labs will save energy.	31,200 KWh/yr (for one mixer)	1210	60	0.6 month
Option 4- Install distillation unit Installation of distillation unit will recover the waste solvents generated from the company to be reused again.	7900 litres of solvent/yr	3860	31,000	8 yr

Consider the following questions:

1. What options might be highest priority to implement? Why?
2. What factors might lead to prioritizing options that have longer payback periods?
3. Which option(s) might require more detailed financial analysis? Why?
4. What information would you want to know about Option 4? Compare your thoughts with the information below. What other information would you want to know before selecting the option?

Option 4 - Install distillation unit for waste solvents reuse

The solvents wastes that are resulting from cleaning the containers after filling the coloured paints are collected in barrels to be disposed off. Installation of distillation unit is an option for recovery the solvents wastes and reuses it again.

Environmental benefits

- Reduce the quantities of solvent wastes
- Reduce the toxicity of the wastes, because it considered as hazardous wastes.
- This option will increase the possibilities of recycling the waste streams.

Economic feasibility

- Amounts of waste solvents generated:
  - White spirit = 4000 Litres/yr
  - Toluene = 2000 Litres/yr
  - Xylene = 1900 Litres/yr
- The total amounts of waste solvents are 7900 Litres/yr = 25 Litres/day
- Cost of solvent = 0.25 JD/L
- Assume the solid content in the waste solvent = 5%
- Distilled solvent = 7900 L/yr * 0.95 = 7505 L/yr
- The cost of distilled solvent that will be reused again = 0.25* 7505 = 1876 JD/yr
- Fees for disposing the waste solvent into hazardous site = 296 JD/Ton
- Ton of waste solvent = 4000 * 0.78 + 2000 * 0.866+ 1900 * 0.866 = 6.5 ton/yr
- Total fees = 296 * 6.5 = 1924 JD/yr
- Transportation cost of the waste solvent into hazardous site = 8*40 = 320 JD/yr (40 JD/trip)
- Solid waste generated from the distillation unit = 0.05 * 6.5 = 0.33 ton/yr
- Fees cost = 0.33 * 296 = 98 JD/yr
- Transportation cost = 16 JD/yr
- Need to run the distillation unit for one hour daily to distil the solvent
- Electricity consumption = 12 KWh
- Power cost = 12 * 312 day/yr * 0.039 JD/KWh = 146 JD/yr
- Total saving = (1876 + 320 + 1924) – (98 + 16 + 146) = 3860 JD/yr
- Installation cost of the distillation unit (DSC-100) = 31,000 JD (33,000 €)
- Payback period (P) = 31,000/ 3,860 = 8 yrs

Technical and organizational considerations

- This option will promote the on-site reuse of the solvent.
- This option implementation needs qualified workers and extra training.
- It will create less waste, if it is operated in good condition.
- It can be implemented inside the plant area, outside the production area.

6.4 Factors for successful implementation

The success of CP at your facility will ultimately come down to effective implementation. Following is a summary of six factors introduced throughout this Module that are keys to successful CP implementation.

- **Involve everyone** at the enterprise (sections 3.1 and 4.1)
    - CP will only be successful if everyone is involved, as CP actions affect everyone. In addition, the more people are involved in identifying problems and thinking about solutions, the more likely successful implementation is likely to be.
- **Secure management support and commitment** (section 3.1)
    - The management of an enterprise has to set the stage for the CP in order to ensure cooperation and participation of the staff members. Management commitment should include involvement in decision-making, providing necessary training and awareness-raising meeting for employees, and rewarding project results and improvement efforts. Management is also responsible for ensuring the availability of required financial and human resources needed to implement CP actions.
- **Establish roles** to coordinate, supervise, and monitor implementation **and hold employees accountable** (sections 3.2 and 3.3)
    - All management and staff need to know what they are expected to do and who to turn to for certain actions and decisions. At least one, if not multiple (for example, an EIT), person should be the go-to person in charge of organizing initial CP actions (setting up a waste-walk or an EIT meeting), ensuring everyone who should be involved is, and ensuring decisions are made (by whomever is in charge of making them) and implemented in a timely fashion. In addition, all employees should be held accountable for their roles and responsibilities involving CP.
- **Track and measure progress** over time (section 4.2)
    - Tracking and measuring progress of CP activities encourages continuation of efforts, provides competitive reasoning for implementing CP (such as lowered costs), and allows you to reward successful implementation. It also allows you to determine if you have set realistic and measureable actions and timelines for implementing CP actions, or if new actions or modifications may be needed.
- **Make actions visible, tangible, and easy to follow** (sections 3.3, 4.2 and all of chapter 5)
    - The key here is to make it easy for everyone to implement CP actions, and to see progress as a result of those actions. This encourages people to continue to implement the actions and creates a sense of pride and community at an enterprise when people can see and

understand the impact of implementation (for example, dollars saved by turning off the lights or number chemical spills prevented).

- **Conduct continuous improvement** (section 4.1)
    - By implementing many of the approaches discussed in this module - incorporating into CP into SOPs, assigning clear roles and responsibilities, including CP in 5S, and collecting metrics on performance, to name a few – you have laid a groundwork for continuing to address CP over time. It is important that the activities you learned about in this Module are not just conducted once and then forgotten, but are periodically reviewed and implemented again and again to identify what is working well and what needs improvement. This will ensure that your understanding of environmental wastes and risks at your facility is up to date and that you can identify future priorities and update action plans accordingly.

Exercise 12: Creating the setting for successful implementation

Looking back across the CP opportunities you identified via the exercises in this Module, describe steps you can take to ensure that you address the following factors:

Involve everyone

_____

_____

_____

Secure management commitment and support

_____

_____

_____

Establish roles and hold employees accountable

_____

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_____

Track and measure progress

_____

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Make actions, visible, tangible, and easy to follow

_____

_____

_____

Conduct continuous improvement

_____

_____

_____

7 Annex

7.1 SOP example

Following are excerpts from the 297th Cargo Transfer Company Environmental SOP for Used Product Reclamation Point (UPRP), Energy Conservation and Recycle Program; 06 January 2005.

SECTION 2. Used Product Reclamation Point (UPRP)

General Operating Procedures

a. All drums must be metal, properly labeled with contents and kept securely closed except when filling.
b. Used products must be segregated; mixing will prevent recycling or recovery.
c. Personnel handling used products should always be properly equipped with gloves and eye protection.
d. Schedule turn- ins so that no more than one drum of each product is on hand. When turning in products, properly fill out DA Form 3161 with appropriate turn in product type. Turn in DA Form 3161 to appropriate ECO in the motorpool for filing purposes. A copy will also be needed to transport and turn in to the classification unit.
e. Ground fuel containing drums to prevent fire.
f. Only tumbler locks are permitted on the building.
g. Buildings need to be marked with one NFPA 704 Hazard Identification System and 2" letters: "NO SMOKING WITHING 50 FEET" on at least one side. Contact the Fire Department at 288-5820 with questions.
h. Store one 10lb ABC or 15 lb CO2 fire extinguisher outside the UPRP.

SECTION 3. Energy Conservation

Administrative area:

a. Turn off lights when not required.
b. Keep thermostats set at 70 degrees Fahrenheit during heating season, if applicable. If overheating occurs, reduce heat by shutting off radiators, not by opening windows. Windows may be opened only when all the radiators in the area have been completely shut off and sufficient time allowed for them to cool.
c. On multiple story buildings, keep fire doors shut.
d. Turn off ventilation systems when facility is not occupied.

Electrical: (All areas)

a. Discontinue outdoor lighting, which is not required for mission safety or security purposes. Eliminate all of the private outdoor decorative lighting installed on the facilities.
b. Eliminate air conditioning except where needed to provide a controlled environment for special purposes such as automatic data processing, etc. Thermostat settings will not be lower than 80-82 degrees Fahrenheit in these areas.
c. Consider energy efficiency when purchasing new equipment.
d. Turn off electrical machines such as fans, typewriters, calculators, and copies when not in use.

7.2 List of Improvement Ideas

Session 2		
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4.		
5.		

Session 3		
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Session 4		
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Session 5		
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Session 6		
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Session 7		
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7.3 Enterprise Improvement Plan(EIP)

REF		PROJECT & SUB-ACTIVITIES	PERSON RESPONSABLE	PROGRESS INDICATOR	START DATE	PLANNED FINISHING DATE	ACTUAL FINISHIING DATE	COMMENTS
1								
	1.1							
	1.2							
	1.3							
	1.4							
2								
	2.1							
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