# Cleaner Production Tips
# For Small and Medium Industries

**Department of Environment, Malaysia**

First Edition 2011

# Cleaner Production Tips for Small and Medium Industries

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# Contents

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# Foreword

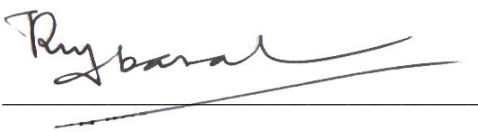
"Cleaner Production Tips for Small and Medium Industries" is intended to facilitate implementation of Cleaner Production (CP) in Small and Medium Industries. I am delighted that this book is being published among many other materials by Cleaner Production Unit, Department of Environment (DOE), Malaysia. The options given in this book are generated from various CP audits and visits conducted by DOE and through available literature.

Cleaner Production practices have become a necessity since the Malaysian government has expressed its commitment to reduce carbon footprint to the international community to overcome global warming issues. Therefore, DOE has taken a leading role in motivating and promoting the CP initiatives with focus on SMEs. In implementing CP initiatives, DOE is taking a pro-active approach where its officers are being trained to become advisors and not only as enforcement officers.

It is my sincere hope that the Malaysian industries will rise to the challenges of implementing Cleaner Production options and this book could be helpful in meeting more challenges. DOE will continue to take many more initiatives in promoting Cleaner Production,

Good luck!

Yours Sincerely;



***Dato' Hajah Rosnani binti Ibarahim***
Director General
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April 2011

# Editor's Note

This book can be used as a guide to facilitate CP option generation for Small and Medium Industries. It outlines the general framework and methodologies necessary to systematically generate CP options. Options are given in a very generic form and not constrained to any specific industry. Some of the examples here may or may not be applicable but could be used as an example or starting point.

The simplified and generic examples of options will make them applicable for many industries. The materials and information developed herein is intended to cater a broad spectrum of users and may not entirely be relevant for your purpose. Some sections may require some alterations to suit the requirements of a particular premise.

Following aspects will be covered in this book:

- Description of the option.
- Tips to implement the option will be described if information is available.
- Precautionary steps required in implementing the options will be also given to the users as much as possible.
- All the possible benefits from implementing the options will be included.
- Wherever available, success stories related to a particular CP options will be given.

The contributors of this book welcome any feedback and if possible, the feedback will be taken into consideration for future updates.

***Ir. Dr. Abdul Aziz Abdul Raman***

# Disclaimer

Please note that the information provided in the "CP Tips for Small and Medium Industries" are recommendations only and the implementation are the responsibility of the readers. Care must be taken in implementing the options. Department of Environment, Malaysia shall not be liable for any loss or damage incurred due to the usage of the CP options contained in this book. Please be advised that you should also verify the accuracy of any information before implementing any options.

# Further Information

Further clarification and information regarding the CP options can be obtained by contacting the Cleaner Production Unit at Department of Environment. The contact details are as follows:

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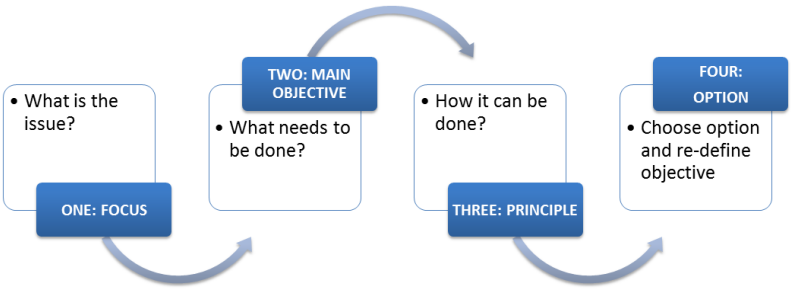
# Cleaner Production Tips for Small and Medium Industries

# Chapter 1

# About This Book

Cleaner Production (CP) implementation programmes may face some difficulties initiating ideas for option generation. Once an issue has been identified, a good starting point is a clear definition on the emphasis and specific objective of an option. In other words, one should start by asking ***What is the issue (problem)?*** followed by ***What needs to be done?*** and finally ***How it can be done?*** These leading questions will guide readers to generate options for specific issues identified systematically.




The CP options included in this book will be grouped by its focus or emphasis for clear representation and easy understanding. The main focus areas are reduction in the consumption of water & energy and reducing waste generation.

### (a) *Options to reduce water consumption*

Water consumption is emphasized because many industries consume large amounts of water and many more consume water above benchmark levels. In most cases, water consumption is directly related to wastewater generation. Therefore, the importance of this emphasis stretches over a vast area from reducing environmental impacts to maintaining monetary sustainability. The following illustration gives simple idea on the direct and indirect benefits of reducing water consumption.

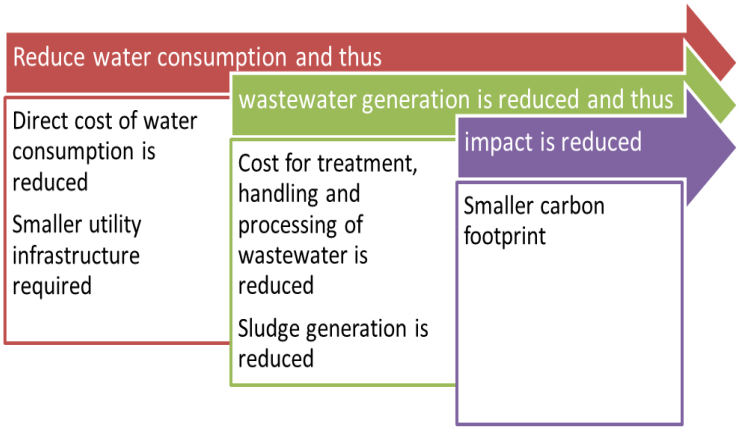



**Figure 1.1: Direct and indirect benefits of reducing water consumption**

The reduction in water consumption will reduce wastewater generation and thus lower cost of treatment and sludge generation. All these activities will contribute positively for carbon footprint reduction.

### (b) *Options to reduce energy consumption*

Globally, industries consume about one third of the energy produced which contributes to about 36% of $CO_2$ emission. In Malaysia, energy wastage is one of the highest ranked losses compared to any other waste. Major contributors can be identified as inefficient and poor power management.

Even though energy costs in Malaysia is still relatively low in the global standing partly due to subsidy, increase in power generation and fuel costs validates the emphasis to reduce energy consumption. Industrial and commercial use of energy contributes to more than half of global energy consumption.

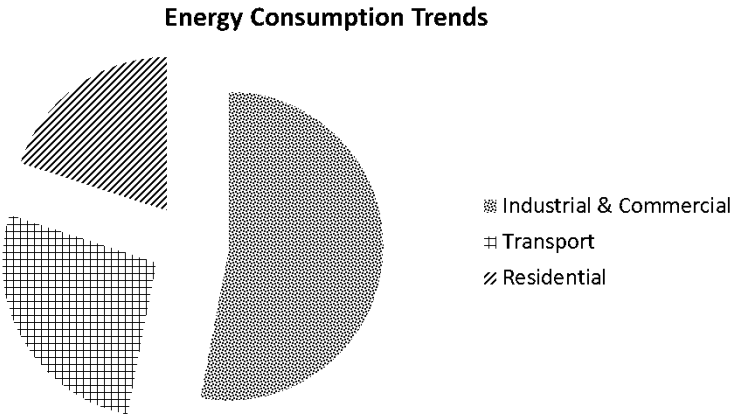



**Figure 1.2: Energy Consumption Trends**

Main uses of energy in the industry include heating & cooling, motors, steam generation, compressors and lighting. Therefore, energy consumption is a significant component contributing to both environmental impact and cost incurring resources which require much focus.

### (c) *Options to reduce waste generation*

Waste generation other than wastewater will be grouped together because there are wide varieties of wastes. This includes raw material and product loss/waste, other solid and schedule waste or any other gaseous, liquid or solid materials discarded as waste, sludge from waste water treatment plant, rejected products and packaging materials. These wastes typically require extensive handling and majority end up in incinerators and landfills. A general approach to generate options for this aspect is more

challenging because of the wide variety, nature and compositions of the wastes involved. The best strategy is a thorough industry dependant approach.

# Chapter 2

# The Need for CP Options

Cleaner Production is primarily implemented to reduce material and energy wastage which will in turn reduce impacts, increase efficiency and eventually reduce carbon footprint. Furthermore, the premise can also benefit in more aspects which will increase productivity and profit. Among the benefits are as follows:


**Figure 2.1: Benefits of CP**

In summary, implementation of CP is capable of providing multiple benefits to the premise. The tips suggested in this book are only a fraction of options available and many others can be generated with proper understanding of CP.

A major step in the implementation of CP is the CP audit which will provide baseline information on the material & energy consumption and waste generation based on the current practices in the premise as well as the equipment. The outcome and findings of the audit process is carefully analysed so a realistic CP target can be defined. This important information will give a clear standing on the opportunities and challenges involved and allow CP auditor to set targets and generate options to achieve these targets.

A simplified diagram of the CP implementation programme below shows where the option generation step stands.

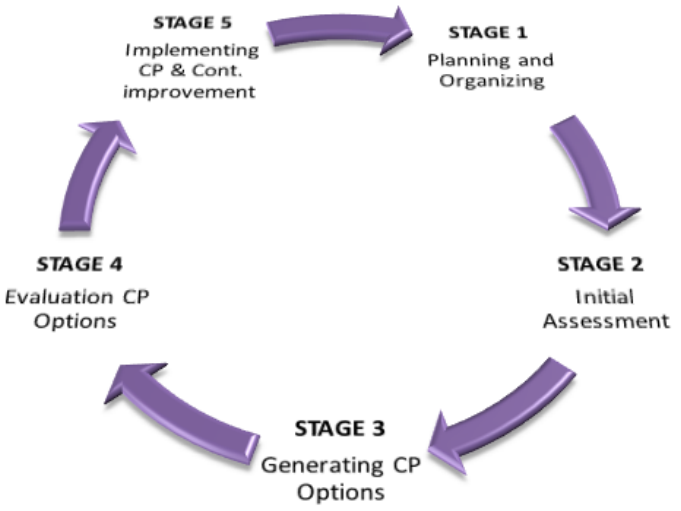



**Figure 2.2: Steps in a Cleaner Production Programme**

# Chapter 3

# The Categories of CP Options

In conjunction to the baseline information obtained from the CP audits, CP outcomes or targets can be defined by giving emphasis to the specific focus groups (i.e. reduce water consumption, reduce energy consumption, or reduce waste generation). The appropriate approach need to be carefully considered for generating CP options. While environmental impact and carbon footprint reduction might be the ultimate targets for CP options, industries are generally more receptive to options that reduce operating cost and increase profit. In addition, it is not sufficient that an option promises savings and/or profits, it must also do so within an attractive period of time.

CP options implementations can be classified into six categories. Based on the experience of the author of this book, the typical cost requirement in many industries can be summarized as given in the Table below:

**Table 3.1: Typical Cost Requirement for CP Options Implementation**

| Type | Investment required | Rate of return | Typical Percentage of CP Options under this category |
|---|---|---|---|
| 1 | No | Immediately | ~15- 30 % |
| 2 | Small | 1-6 months | ~10- 20 % |
| 3 | Significant | 1-6 months | ~5- 10 % |
| 4 | Moderate | 1-3 Years | ~5-10 % |
| 5 | High | More than 3 years | ~5- 10 % |
| 6 | Significant/ High | No monetary return | ~10- 20 % |

For each option that will be described in this book, the category of CP options will be indicated. With the help of the category, the premise could make decision on prioritising the CP options according to the need and return expected.

# Chapter 4

# Evaluating CP Options

Evaluating CP options is an important step before deciding the options to be implemented. The following format is recommended to identify and/or prioritize the CP options to be implemented.

**CP OPTION EVALUATION FORM**

| | | | |
|---|---|---|---|
| **Issues** | : | | |
| **Area** | : | | |
| **Source &/or reasons** | : | | |
| **Option** | : | | |
| **Category of option** | : | | |
| **Possible challenges** | : | **Type of challenges** | **Tick √** |
| | | No expertise | |
| | | Top management's commitment | |
| | | Production cannot be stopped | |
| | | Too risky | |
| | | May have effect on quality | |
| **Input required** | : | **Input required** | **Tick √** |
| | | 1. Technology | |
| | | 2. Manpower | |
| | | 3. Training | |
| | | 4. Awareness | |
| | | 5. Process Change | |
| | | 6. Operation parameters change | |
| | | 7. Material change | |
| | | 8. Design change | |
| | | 9. Standard operating procedure | |
| | | 10. Monitoring | |
| | | 11. Additional control | |

| | | | |
|---|---|---|---|
| **Input required (cont'd)** | | 12. R&D | |
| | | 13. Approval from authorities | |
| **Investment Cost** | : | **Item** | **Amount Required (RM)** |
| | | 1. Electrical work | |
| | | 2. Purchasing equipment | |
| | | 3. Construction work | |
| | | 4. Shut Down loss | |
| | | 5. Man power cost | |
| | | 6. Cost of financing | |
| | | 7. Others | |
| | | **Total (A)** | |
| **Additional operational cost due change/ modification (monthly rate)** | : | **Item** | **Amount Required (RM)** |
| | | 1. Manpower | |
| | | 2. Electricity | |
| | | 3. Steam | |
| | | 4. Fuel | |
| | | 5. Maintenance | |
| | | 6. Treatment | |
| | | 7. Others | |
| | | **Total Cost (B)** | |
| **Saving (monthly rate)** | : | **Item** | **Saving (RM)** |
| | | 1. Man power | |
| | | 2. Electricity | |
| | | 3. Steam | |
| | | 4. Fuel | |
| | | 5. Maintenance | |
| | | 6. Treatment | |
| | | 7. Others | |
| | | **Total Saving (C)** | |
| **Payback period** | : | **A/(C-B) months** | |
| **Other possible benefits** | : | **Benefit Type** | **Tick √** |
| | | 1. Improved quality | |
| | | 2. Improved images | |
| | | 3. Safer operation | |
| | | 4. Less riskier operation | |
| | | 5. Better motivation | |
| | | 6. Better working environment | |
| | | 7. Lesser environmental issues | |

| | | | |
|---|---|---|---|
| **Other possible benefits (cont'd)** | | 8. Reduction in carbon footprint | |
| | | 9. Others | |
| **Merit of implementation** | : | **Merit** | **Tick √** |
| | | Implement immediately | |
| | | Implement within six months | |
| | | Implement only if finances are available | |
| | | Keep it as future plan | |
| | | Drop it for at least 10 years | |
| | | Ignore | |
| **Documentation required if implemented** | : | **Type of documentation** | **Tick √** |
| | | Paper documentation | |
| | | Video documentation | |
| **Monitoring plan (describe)** | : | | |
| **Prepared by** | : | | |
| **Confirmed by** | : | | |

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# Chapter 5

# Focus of CP Options Generation

Cleaner Production implementation programmes generally targets carbon footprint reduction. However, this eventual target must be preceded by other intermediate output such as reduction or saving in cost and many other outcomes which are described in **Chapter 3**.

Typically, CP options also focuses on opportunities on saving energy, material and improve safety aspect.

Savings in energy include reducing consumption and minimizing wastage for electrical and heating & cooling. Material savings include reduction in consumption of raw and other materials (packaging, treatment chemicals, fuel, water, cleaning chemical and others); and minimize waste generation in terms of quantity and quality (water solid and others). The safety aspect is also included in CP concepts because issues resulting from safety mismanagement will result in loss of material and energy at varying degrees. So, preventing safety related incidences are potential material and energy savers.

Within industrial premises, the common methodology to achieve the desired CP outcome is generically described in **Chapter 7**. The methods include housekeeping, change of material, design modification, operational modification, application of new technologies, staff training and recycle &

reuse. These methodologies can be utilized to identify a specific option for any of the entities chosen.

Theoretically one can generate unlimited number of options in a typical premise. Many examples will be given in Chapter **8, 9** and **10**. However the underlying principles in generating option for each entity can be summarized into few basic principles. These principles are explained in Chapter **6** and the respective example will be given in subsequent Chapters.

It is very important for the CP implementers to understand the thought process involved in generating and evaluating CP options. The overall thought process is demonstrated in Figure 5.1. below:

| Entities targeted | Principles of CP option generation | Implementation methodology | Intermediate output | Eventual output |
|---|---|---|---|---|
| -Energy<br>-Material<br>-Safety | -Change T*<br>-Change t*<br>-Change P*<br>-Others | -Housekeeping<br>-Design modification<br>-Operational modification<br>-Change of raw material<br>-New technologies<br>-Staff training<br>-Recycle & Reuse | -Direct cost reduction<br>-Improve product quality<br>-Reduce waste generation<br>-Reduce energy consumption<br>-Reduce risk<br>-Improve reputation<br>-Others | -Carbon footprint reduction<br>-Reduce environmental impact<br>-Others |


*T: temperature, t: time, P: pressure

**Figure 5.1: CP option generation process**

# Chapter 6

# General CP Options Principles

For each methodology mentioned in Chapter 5, there are underlying principles that can be used for generating CP options. From these underlying principles, many specific options can be generated. The underlying principles for each entity are as follows:

### 6.1. Energy

#### 6.1.1. Electrical

##### 6.1.1.1. Reduce time of consumption

For electrical consumption, reducing time of consumption should be targeted as the first choice of CP option because it is one of the easiest principles to be implemented. By reducing time of usage kWhr consumption will be lower as total consumption of electricity is given by formula below:

**Consumption (kWhr) = rating of the electrical appliances (kW) X usage time (hr)**

##### 6.1.1.2. Use appropriate capacity

Overcapacity (for kW rating) or over-sizing results in energy wastage. One may need to evaluate the appropriate capacity (kW) of the appliances needed for the task at hand and

reduce it accordingly. One more aspect is the speed of the electrical motors which are operated. Higher speed operation results in higher energy consumption. This can be managed through use of simple control measures.

#### 6.1.1.3. Use of appropriate materials and/or technology

Electrical appliances of the past can be massive energy consumers and waste a lot of energy. Due to advances in technology and environmental consciousness, many energy saving electrical appliances are available in the market. Using newer and more energy efficient material and/or technology are a basic principle for generating many energy saving CP options.

#### 6.1.1.4. Use of renewable energy

Wherever possible, use of renewable source such as biofuel, solar, wind and geothermal energy should be considered because the production of these energies have smaller carbon footprint.

### 6.1.2. Heating & Cooling

#### 6.1.2.1. Reduce time (of process)

Reducing process time for processes that involves heating and cooling will reduce energy consumption because energy consumption is directly proportional to process time.

#### 6.1.2.2. Reduce/increase temperature

Heating and cooling process consumes energy to change the temperature of a process stream or product. By reducing/increasing the set temperature the energy requirements will be reduced due to shorter temperature gradient.

#### 6.1.2.3. Recovery heating/cooling energy

Hot/cold streams still contain energy which possesses opportunity for energy that can be recovered. Energy recovered will supplement and thus reduce overall heating/cooling requirements.

#### 6.1.2.4. Use renewable energy

Similar to electrical energy, renewable source such as biofuel, solar, wind and thermal energy should be considered because these energies have smaller carbon footprint producing sources.

#### 6.1.2.5. Use of appropriate materials

Appropriate material selection is important because the material type, design and features attribute to the efficiency of energy usage. For example, material type and shape of the heating or cooling coil of heat exchangers determine the heat transfer coefficient and hence the efficiency of the operation.

#### 6.1.2.6. Eliminate material loss

Large amount of energy may be loss through material discharged to the environment. For example, steam that contain large amount of energy must be prevented from being lost to the environment through leakages.

### 6.2. Material

#### 6.2.1. Prevent loss of material

Material loss through leakages, incomplete reaction or other ways contribute to waste generation, unnecessary overconsumption and more importantly (to the industry) additional costs incurred. As such, even though the identification of sources for material losses may be exhaustive, it should not be overlooked.

### 6.2.2. Maximise usage of material

An important principle in CP is maximising material use. This can come in many forms which include but is not limited to reuse, recycle and even finding markets for by-product and waste material (which will be used in other premises). This will directly reduce waste generation and reduce new material consumption. Maximising product output by minimising off-spec product must be also instituted by the premise.

### 6.2.3. Material with less impact to environment

Alternative materials are constantly being developed as supplement and substitute to current materials with added features like improved activity, increase yield, reduce energy requirement and increased stability (i.e. inert, less toxic). Application of this principle will eventually lessen environmental impact for a particular process or premise.

## 6.3. Risk Management

### 6.3.1. Minimise/eliminate probability of the risk from happening

Potential accidents and mishaps can be identified within a premise. By finding the root cause for these potential occurrences, countermeasures can be identified thus reducing the probability for occurrence. In the CP concept, an accident is always viewed as carbon footprint producing events.

### 6.3.2. Minimise/eliminate severity of consequence

After the probability of a risk from occurring are minimised as much as possible, attention must be focused to find opportunities to reduce severity of an occurrence. This will reduce possible losses, which include material loss or damage, loss of resources, injuries to workers or even loss of lives.

# Chapter 7

# CP Options Through Various Methods

The CP options available are very diverse and can range from minor operation change to major design modification or technology change. However, they principally can be grouped by the methods of implementation. There are seven methods that are commonly used in the industries as follows:

**1. Housekeeping**

Housekeeping can take many forms but are mainly focused on preventing material & energy losses, minimizing waste and improving operational & organizational procedures. Housekeeping items are first in the list of CP options because the implementation of these options usually require low capital investment with faster or even immediate return. Thus, this method is surely stands front runner for implementing CP. Some of the housekeeping activities are as follows:

- Keep premise clean
- Repair leakages
- Keep equipment dry
- Do not mix waste
- Label items properly
- Do not overstock raw material
- Careful with expiry date
- Scheduled maintenance of equipment

It is proven that in some cases good housekeeping can reduce up to 30% waste and improve general productivity. Normally it does not take much effort to implement.

**2. Design modification**

Design modification can range from minor alteration to major design modification. For example, a minor adjustment by incorporating a simple chute system may reduce or even eliminate spillage of a solid material being conveyed into a container, whilst alternatively major modifications can be implemented which may involve replacement of unit operation or acquiring new process lines. Depending on the industry, some design modifications may require in-depth technical knowhow and a thorough study to be conducted before a suitable option can be designed.

In some cases CP options that involve design modifications require a thorough study to be conducted and an in-depth technological knowhow.

**3. Operational modification**

Operational modification refers to changes or optimization of processing parameters that involve time, temperature, pressure, sequence and many other relevant parameters. For example, by reducing operating time energy consumption can be reduced. Another example is combining two activities into one unit operation or eliminating a step altogether. More detailed examples can be found in preceding chapters.

**4. Change of raw materials**

Changes in raw material are commonly considered to resolve some of the issues. Then substitute raw materials may be considered to achieve the following:

- To obtain higher yield
- To lower production and/or processing time

- To generate less waste
- To generate more benign by-products or waste
- Easy handling (Less toxic materials)
- Lower energy consumption (i.e. for handling, production and storage)

**5. Use of alternative or new technologies**

Newer technology may be considered if they can improve productivity, reduce material loss, reduce waste generation, produce more benign waste or reduce energy consumption. The new technologies may be incorporated into an existing system as a supplement, or they may replace entire system or part of a system. More detailed examples can be found in preceding chapters.

**6. Staff Training**

Studies have shown that untrained staff can lead to higher waste generation, reduced productivity and increasing risk. One way to implement CP is to train the staff in required areas. Training is also required when CP is implemented by changing Standard Operating Procedure or where design and/or operational modifications have been made.

*Picture above shows factory staff being trained in-house and on-the-job.*

## 7. Reusing and Recycling

Reusing and recycling are two sure way of implementing CP. It could be a cheap or an expensive CP options to be implemented.

# Chapter 8

# CP Tips for Electricity Saving at a Premise

## 8.1. Detail Options

**TIPS 1/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Installation of automatic shutoff/open switch. |
| Description | : | Equipment which is not in use/not required should be switched off. However in many industries this is not done as switching off is done manually. Incorporating shut off switch coupled with a timer may save electricity. |
| Application | : | Lighting systems, air-conditioning systems, motors for specific application (i.e. conveyor, escalators). |
| Outcomes | : | Reduce direct electricity cost by preventing wastage. |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| | | Reduce Life Cycle Cost (LCC). |
| | | Lengthen equipment life. |

| | | |
|---|---|---|
| Methodology | : | Automatic switches can be easily retrofitted onto control panels and switch-boards. |
| Tips | : | Normally the shut off/open switches can be attached with a sensor as well. For example lights can be attached with light intensity sensor. |
| Category of option | : | Small investment and return within 6 months. |
| Financial consideration | : | Estimated savings can be calculated using the following formula:<br>Saving (RM) = total kW for total duration of shutdown x RM0.30 |

**Pictures /diagram**

*Above are some examples of automatic switches*

| | | |
|---|---|---|
| Other relevant information | : | Motors can be also fitted with timers or any other relevant sensor (like pH sensor in the waste water treatment plant). |
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 2/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Install motor efficiency controller. |
| Description | : | It improves the efficiency of electric motors operating at constant speed and under variable loads by continuously monitoring the power consumption of the motor and reduces the voltage when the motor load decreases. |
| Application | : | Motors for various applications (i.e. pumps, homogenizers, compressor drivers, escalators drivers, convey drivers). |
| Outcomes | : | Reduce direct electricity cost by preventing wastage and increasing motor efficiency. |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| | | Reduce Life Cycle Cost (LCC). |
| | | Increases motor lifetime. |
| Methodology | : | The controller can be introduced in single phase or three phases and can be installed on new equipment or as a retrofit product. |
| Category of option | : | Moderate investment but return within 1 year. |
| Financial consideration | : | Estimated savings can be calculated using the following formula:<br>Saving (RM) = total reduction in kWh after installation x RM0.30 |

**Pictures /diagram**

*Motor energy controllers*

| | | |
|---|---|---|
| Other relevant information | : | The controller can improves the efficiency of motors in applications such as crushers, granulators, mixers and extruders. |
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 3/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Install a lighting energy controller. |
| Description | : | It controls and stabilizes the voltage provided to lighting elements. |
| Application | : | Indoor and outdoor lighting systems. |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| Methodology | : | The controller can be introduced in single phase or three phases and can integrated into existing lighting systems. |
| Category of option | : | Moderate investment but return within 2 years. |
| Financial consideration | : | Estimated savings can be calculated using the following formula:<br>Saving (RM) = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**

*Lighting energy controllers*

| | | |
|---|---|---|
| Other relevant information | : | Typical savings of about 35% is achievable. Units normally come built in with timer control system. |
| Success Story | : | A petrol station with outdoor lights and convenient store operating 24 hours a day recorded between 20-25% electricity savings by installing a controller coupled with a built in timer to control lighting for the station which illuminates after sunset and the convenient store operating 24 hours a day. |
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 4/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Use low power lights/energy saving bulb / LEDs. |
| Description | : | There are many low energy consumption light source available in the market. They include but are not limited to compact fluorescent light bulbs, high-intensity discharge and light emitting diodes (LEDs). The installation is very easy and you can get your supplies without any issues. |
| Application | : | Indoor and outdoor lighting systems. |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce Life Cycle Cost (LCC) (i.e. LEDs have 10 times longer life compared to fluorescent and 100 times longer life) . |
| Methodology | : | Lighting systems can be purchased readily and requires little or no structural modifications for installation. |
| Tips | : | Automatic controls such as timers and light sensors can further save electricity by turning lights off when not in use.<br>Dimmers also save electricity when used to lower light levels. |
| Category of option | : | Small investment and return within 6 months. |
| Financial consideration | : | Estimated savings can be calculated using the following formula:<br>Saving (RM) = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**

*Pictures of two types of energy saving light bulbs*

| | | |
|---|---|---|
| Other relevant information | : | Various brands and specifications are available in the market. One has to choose the right rating for applications. The saving can range from 2-50% from conventional lighting. |

**TIPS 5/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Install inverters. |
| Description | : | Inverter is a device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. This will allow it to act as a variable speed drive which can regulate the speed of the motor, and in turn the speed of the pump or fan, by controlling the energy that goes into the motor, rather than restricting the flow of a process running constantly at full speed. |
| Application | : | Can be retrofitted into air conditioning systems, pumps systems, fans or any motor driven systems. |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce Life Cycle Cost (LCC) (i.e. by reducing motor stress especially on long runs). |
| Methodology | : | Inverters can be fitted onto existing systems with little or no modifications. |
| Tips | : | Inverters can save up to 60% energy consumption on motors drives. |
| Category of option | : | Moderate to high investment cost depending on the power rating of the motor. However, return can be within 1-2 years. |

| | | |
|---|---|---|
| Financial consideration | : | Estimated savings can be calculated using the following (RM):<br>Saving = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**


*Examples of inverters available commercially*

| | | |
|---|---|---|
| Other relevant information | : | Inverters also make it possible to completely stop a motor when it is not required and soft-starting (which cause less tress) when it is required. |
| Technical Justification | : | Saving is obtained because you can operate the motor at the required speed and duration. For example, in an air conditioning system, an inverter can continuously regulate its output by altering the compressor speed in response to cooling demand. |

**TIPS 6/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Install translucent roof panels. |
| Description | : | By installing translucent roof panel strategically, the number of artificial lighting required can be reduced (if not eliminated altogether for certain time of the day). |
| Application | : | All indoor spaces that utilises artificial lighting may be supplemented by translucent roof panels . |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| Methodology | : | Translucent roof panels can be installed on roofs. Minor or moderate modifications may be required. |
| Tips | : | About 10% of the roof area with translucent light can reduce up to about 20% of the total electrical lighting requirement up to about 4:00 pm on sunny days. These translucent panels can be coupled with daylight harvesting systems to further save energy. |
| Category of option | : | Low investment and return within 6 months. |
| Financial consideration | : | Estimated savings can be calculated using the following (RM):<br>Saving = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**

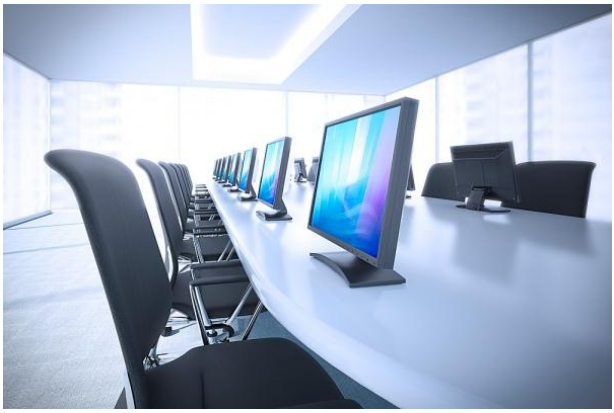
*A picture of an installation of a translucent roof panels*

| | | |
|---|---|---|
| Other relevant information | : | Choose a panel type that requires less maintenance and resistant to degradation. Take into consideration climate conditions on the premise. |
| Success Story | : | Installation of 10 transparent roof panel in a company in Shah Alam resulted in 12 Mercury Lights (400 W) not being used from 4:00 to 6:00 pm, resulting in RM 120 electricity saving per month. |
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 7/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Install daylight harvesting system. |
| Description | : | Daylight harvesting systems regulates artificial light usage. When there is sufficient natural lighting the contribution of artificial lighting is being reduced which is usually achieved by incorporating light sensors. |
| Application | : | All indoor spaces that utilises artificial lighting may be supplemented by daylight harvesting systems. |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| Methodology | : | Light sensors are normally installed on roofs which will gauge light availability which will regulate artificial light brightness. Minor or moderate modifications may be required. |
| Tips | : | A well designed harvesting system can generate 35-60% energy savings.Spaces with skylights, and corridors, private offices and open cubicles near windows are good candidates for daylight harvesting. |
| Category of option | : | Low investment and return within 2 years. |
| Financial consideration | : | Estimated savings can be calculated using the following (RM):<br>Saving = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**



*Picture shows a computer room illuminated by both artificial and natural lights*

| | | |
|---|---|---|
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 8/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Set air-conditioning temperature at comfort level. |
| Description | : | In many premises the air conditioning system are set at low temperatures which frequently cerates discomfort for the occupants. |
| Application | : | Air-conditioned spaces (i.e. office spaces). |
| Outcomes | : | Reducing electricity wastage and lengthening the lifespan of the air-conditioning system. |
| | | To provide comfort for the occupants (not too cold). |
| | | By setting the system at appropriate temperatures, energy can be saved and it may also help to increase productivity. |
| Methodology | : | Depending on the air-conditioning facilities at the premise, temperatures can be set individually on split units or on centralised units. |
| Tips | : | Comfort level is normally in between 23-25°C. |
| Category of option | : | No investment is required. |

**Pictures /diagram**


*A HVAC thermostat*

**TIPS 9/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Harvest solar energy. |
| Description | : | Solar panels are used as a component to harvest solar energy to generate alternative and supplementary electricity supply for a premise. |
| Application | : | Supplementary electricity generated can be used for lighting or heating purposes on the premises (i.e. to generate hot water). |
| Outcomes | : | Reduce direct electricity cost . |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| Methodology | : | Solar panels are normally installed on roof or open spaces where sunlight can reach panel for the longest period during the day without being obstructed. |
| Category of option | : | Medium to high investments are required and return normally more than 3 years. |
| Financial consideration | : | Estimated savings can be calculated using the following (RM):<br>Saving = total reduction in kW after installation x RM0.30 |

**Pictures /diagram**

*Examples of solar panels installed on roofings.*

| | | |
|---|---|---|
| Other relevant information | : | Integration of energy. Solar cells usually connected in series in modules, creating an additive voltage. Connecting cells in parallel will yield a higher current. |
| Caution | : | A thorough feasibility study should be conducted to determine the return for this option. |
| References | : | [1]. U.S. Department of Energy's Energy Information Administration. |

**TIPS 10/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Encourage good electricity usage practices. |
| Description | : | Electricity usage can be reduced simply by minimizing and/or eliminating unnecessary use of electricity (i.e. switching off lights in unoccupied room). |
| Application | : | Staff members within the premise. |
| Outcomes | : | Reduce direct electricity cost. |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| | | Increased awareness among workers. |
| Methodology | : | Awareness car be harnessed by training and programmes which can be conducted periodically.<br>Create a working culture within the premise. |
| Tips | : | Continuous awareness programs need to be conducted. |
| Category of option | : | Low or no investment required. |

**Pictures /diagram**

*Left: Training conducted on good energy saving practices.*

*Right: Training on energy saving on the job.*

**TIPS 11/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Optimize process temperature. |
| Description | : | Temperature is an important parameter in many industries. Process temperatures are normally dictated by Standard Operating Procedure. Reducing high temperatures or increasing low temperatures may reduce loads on equipment and energy consumption and should be considered as good opportunities for saving. |
| Application | : | Processes and equipment that require heating (i.e. reactors, cooking vessels, sterilizer, dryers).<br>Storage facilities (i.e. chill rooms, freezers).<br>Utilities (i.e. hot and cold water facilities). |
| Outcomes | : | Reduce direct electricity cost. |
| | | Reduce fuel requirement where applicable. |
| | | Opportunity of increase productivity and efficiency (i.e. of the process). |
| | | Opportunity to increase product quality. |
| Methodology | : | Depending on the process, operating temperature can be increased/decreased with or without modifications to equipment involved. A through study needs to be conducted to ascertain the total effects of process temperature change. In most cases experimental and/or research work are required to determine the appropriate temperature required. |

| | | |
|---|---|---|
| Tips | : | This option can be considered as a supplementary to design modification and raw material change options. |
| Category of option | : | No investment required (if no modifications involved) for the change but time and resource required to obtain relevant information and research to determine feasibility of option. |
| Other relevant information | : | Process data and records are important reference data for feasibility analysis. Need to check the compliance for current standard practices or requirements for certain processes. |
| Caution | : | Changing process temperature may affect quality of product and efficiency of process. |

**TIPS 12/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Use split unit instead of centralized air-conditioning system. |
| Description | : | Split units are relatively small and are flexible for zoning and cooling individual spaces. Split units do not require ductwork which can account for about 30% of energy consumption and require more maintenance. Zoning allow units in unoccupied rooms to be switched off and more specific requirements can also be accommodated (i.e. storage room and archives may require extra cooling and strict humidity control). |
| Application | : | All spaces that require air conditioning. |
| Outcomes | : | Reduce direct electricity cost. |
| | | Reduce carbon foot print (on the average 0.59 kg $CO_2$ is emitted per kWh of electricity generated[1]). |
| | | Increased comfort level (i.e. increased productivity). |
| | | Reduced maintenance cost. |
| Methodology | : | Proper sizing is required for individual rooms.<br>Design and installation works is normally carried out by contractors/vendors.<br>Minor or no modifications required for installation. |
| Tips | : | Creating smaller room within a large area may be useful to cater for working space for small number of staff.<br>Maintenance schedule should be drawn out to ensure optimized operation of individual units. |
| Category of option | : | Moderate investment required. Return normally within 1-3 years. |

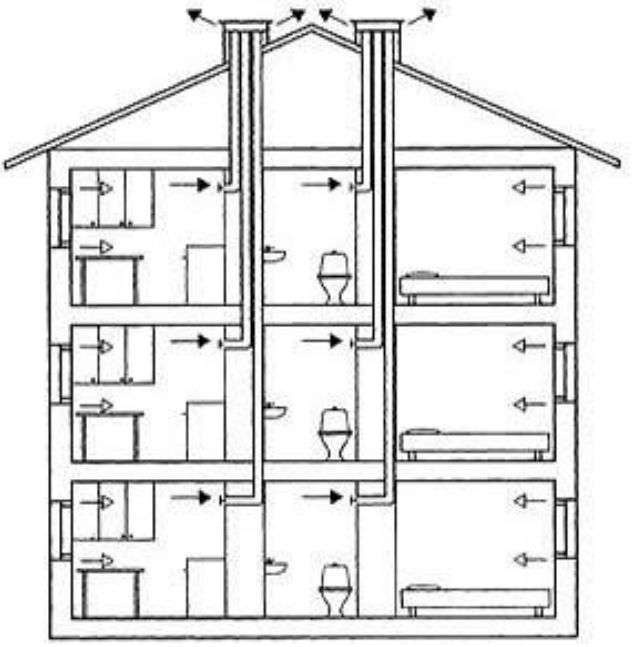
**Pictures /diagram**

*Illustration of an office space being cooled by separate split unit air-conditioning systems with a common external unit*

**TIPS 13/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Reduce head space in spaces. |
| Description | : | In many premises, the buildings are normally built with a lot of head space (between floor and the roof). This causes the air condition requirement to cool the entire space increases. By reducing the head space, the rating required for air conditioning systems can be reduced and electricity consumption can also be reduced. |
| Application | : | All building and premises during design stage.<br>Existing spaces. |
| Outcomes | : | Reduce direct electricity cost. |
| Methodology | : | Review alternative building designs incorporating lower head space.<br>Existing spaces may be incorporated with artificial roofing/ceiling to lower the ceiling. |
| Tips | : | Installing artificial roof may be helpful especially in office areas. |
| Category of option | : | Significant investment required. Return normally within 1-2 years. |

**Pictures /diagram**



*Cross sectional view of a building showing air-flow direction*

| | | |
|---|---|---|
| Technical Justification | : | Aesthetic values should not be overlooked and some specific spaces may require higher headspace for logistics purposes. |
| Caution | : | Reducing the head space must be referred to the building by laws. |

**TIPS 14/ELECTRICITY**

| | | |
|---|---|---|
| Option | : | Run electricity intensive processes at night |
| Description | : | The difference in electricity tariff at certain times of the day (i.e. electricity tariff is lower at night) make it more economical to run more electricity intensive processes at night. |
| Application | : | Any electricity intensive process (i.e. ice and chill water generation) |
| Outcomes | : | Reduce direct electricity cost |
| Methodology | : | Plant operating cycles can be regulated to benefit from low tariffs. |
| Category of option | : | Low to moderate financial requirement for manpower adjustment. |
| Caution | : | Labour costs, local authority requirements and security aspects should be considered during feasibility assessment. |

### 8.2. General Options

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 1 | Use vacuum systems instead of blowing systems. | Vacuum systems create lesser dust problems. | Pneumatic conveyors and dryers. |
| 2 | Repair air leaks promptly. | Leaks in the compressed air lines will increase compressor load due to pressure loss. | Pneumatic systems, compressed air tank and compressors. |
| 3 | Work with minimum pressure required for all operation. | Working with minimum pressure required will avoid excessive and unnecessary load on equipment. | Compressors and pumps. |
| 4 | Do not oversize equipment. | Oversized equipment consumes more energy and resources (i.e. fuel) than necessary. | Pumps, compressors, HVAC, heat exchangers and motors. |
| 5 | Operate equipment near maximum capacity. | Most equipment are designed to operate optimally near its maximum capacity, which will ensure maximum energy efficiency. | Pumps, compressors, HVAC, heat exchangers and motors. |
| 6 | Switch off equipment when not in use. | Equipment which is not in use should be switched off to avoid energy wastage. | Compressor, HVAC, lightings and utilities (i.e. waster heating). |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 7 | Air inlets should be situated in a cool, dry and clean location. | The warmer the air intake, the lower delivered volume of compressed air. | Compressor. |
| 8 | Clean all air filters regularly. | Dirty filters will impart unnecessary resistance and load to the system | Compressor and HVAC. |
| 9 | Institute adequate maintenance. | Equipment which is not maintained properly will break down more often and will not function optimally. | Motors, compressors, HVAC, pumps, and all other equipment. |
| 10 | Close all unnecessary openings to the building. | Openings will cause the loads to HVACs and air-conditioning system to increase. | HVAC, air-conditioners. |
| 11 | Use plastic strip curtains, automatic doors or air curtains. | These installations will reduce unnecessary loading to HVACs at busy openings which cannot be closed. | Large and much trafficked doorways. |
| 12 | Install door closers on all doors. | Open doors will increase loads on HVAC systems. Door closers will prevent doors from being left open unintentionally. | All air-conditioned rooms. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 13 | Use wind assisted ventilators in preference to fans. | Substitute electricity requirement with renewable energy. | Closed rooms and spaces (i.e factory area). |
| 14 | Regularly clean all luminaries, lamps and windows. | Depositions on luminaries, lamps and widows restrict light from passing. | Luminaries, lamps and windows. |

# Chapter 9

# CP Tips for Heat Energy Saving at a Premise

## 9.1 Detail option

**TIPS 1/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Optimize operating temperature and time. |
| Description | : | Process temperature and/or time dictate the output for many industrial processes. For example, the output from a sterilization process is very much dependent on the process temperature and time. The optimisation of these parameters present many opportunities for cost & energy saving, product quality improvement and also increase in process efficiency. |
| Application | : | Any unit operation, activity or process. |
| Outcomes | : | Reduce energy consumption. |
| | | Improve process productivity and quality. |
| Methodology | : | Optimisation can be considered for a particular unit operation or entire |

| | | |
|---|---|---|
| | | process line. A thorough study on effects of parameter change is required. |
| Category of option | : | No investment required for hardware but may require resources to conduct study. |

**Pictures /diagram**

*Gas processing tanks*

| | | |
|---|---|---|
| Caution | : | Reduction in temperature or time need to be ascertained through detail study. |

**TIPS 2/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Reduce or eliminate steam leakage. |
| Description | : | Steam leakages from pipes and joints can occur. These leakages can cause major losses and wastage to process industries. Steam release can also increase risk. |
| Application | : | Boilers, steam pipes and hot water facilities.<br>Unit operations that requires heating (i.e. heat exchangers, evaporators, crystallisers). |
| Outcomes | : | Reduce direct cost (i.e. electricity bill or boiler fuel). |
| | | Increase safety and reduce risk. |
| Methodology | : | Regular maintenance and check-ups on equipment and pipes can identify and prevent steam leakages.<br>Installation of steams traps and other steam related accessories can be used to maximize the steam usage as well. |
| Category of option | : | Small investment may be required. Return can be expected within six months. |

**Pictures /diagram**

A kilogram of steam loss means a loss of 2000-2500 kJ of energy

*Steam release from a valve in a pipeline*

**TIPS 3/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Heat recovery. |
| Description | : | The basic idea is any material released which is not at room temperature still contains energy with potential recovery (i.e. steam condensate, flu gas).<br>Efforts should be made to recover these energies as much as possible, even though it may not be economically feasible in many cases. |
| Application | : | Can be considered for any hot/cold streams throughout the premise. |
| Outcomes | : | Recover energy. |
| | | Decrease fuel and/or consumption (i.e. boiler). |
| Methodology | : | This option can be considered during plant design stage or on existing facilities. |
| Category of option | : | Investment will be dependent on the types of recovery system required. But normally heat recovery system is considered as expensive options. However if the amount of energy to be recovered is significant, economic feasibility can become a reality. |
| Financial consideration | : | Economic feasibility is usually dependent on the amount of heat and material released as modifications require substantial amount of investment. |

**TIPS 4/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Install steam trap. |
| Description | : | Steam traps are used to discharge condensate with a negligible loss of fresh fed steam. Most steam traps involve automatic valves. |
| Application | : | Steam pipes and boiler facilities. |
| Outcomes | : | Reduce energy wastage (i.e. by reducing steam loss). |
| | | Better process productivity and quality. |
| | | Reduction risk and improve safety aspect. |
| Methodology | : | Steam traps are available with many specifications to cater for many loads. The can be integrated into existing systems with minor modifications. |
| Category of option | : | Simple investment requirement and return within one year. |

**Pictures /diagram**

*An example of a steam trap*

| | | |
|---|---|---|
| Caution | : | Steam traps can also contribute to steam loss. Therefore appropriate steam trap selection is important. |

**TIPS 5/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Insulate hot surfaces. |
| Description | : | Energy loss can occur from exposed surfaces that are hot or cold (through radiation and convection). Energy loss can be minimized by installing insulation material on the surface. |
| Application | : | Tanks and vessels (i.e. reactors, storage, mixing).<br>Heat exchangers.<br>Piping system (i.e. steam pipe, hot water lines, chilled water, lines). |
| Outcomes | : | Reduce energy loss. |
| | | Cost reduction for heating and/or cooling (indirect). |
| | | Increase safety and reduce risk. |
| Methodology | : | Insulation can be installed onto existing systems with no modification required. Insulation material can be selected based on requirements and cost. |
| Tips | : | Use removable insulating material to minimise solid waste generation. |
| Category of option | : | Investment requirement can be moderate to significant. Return may be obtained within 1-3 years. |

**Pictures /diagram**

*A vessel (left) and pipe (right) being insulated by insulating material.*

**TIPS 6/ HEAT ENERGY**

| | | |
|---|---|---|
| Option | : | Use closed system for steam/hot water related processes/equipment. |
| Description | : | Steams escaping from open vessels or tanks carry with it a lot of energy which increase heating or energy and fuel consumption. Closed systems avoid such releases and reduce energy loss. |
| Application | : | Heating tanks (i.e. cooking process, scalding).<br>Water baths. |
| Outcomes | : | Reduce energy loss. |
| | | Reduce material loss (water). |
| | | Cost reduction for heating (indirect). |
| | | Increase safety and reduce risk. |
| | | Opportunity to improve product quality (i.e. better temperature control). |
| | | Opportunity to increase productivity (i.e. lesser steam discharge in the processing area will also prevent the area from being uncomfortable for the operators). |
| Methodology | : | Vessels can be modified to incorporate lids and upgraded to prevent steam release. |
| Tips | : | Additional security devices should be considered (i.e. pressure release valves). |
| Category of option | : | Moderate investment required. Return period within 1-3 months can be expected. |

**Pictures /diagram**

*Examples of pressurised cookers*

| | | |
|---|---|---|
| Caution | : | Modification may require upgrade or modification done on process control systems. |

### 9.2 General option

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 1 | Use staged heating/ Cooling. | Staged heating/cooling allows heating/cooling equipment to operate depending on the demand required. Allowance for optimised use of low-level waste heat, low-pressure steam and de-superheated intermediate pressure steam. | HVAC, heat exchangers, furnaces. |
| 2 | Re-examine heating and/or cooling techniques. | Unsuitable heating/cooling techniques are prone to hotspots/cold spots and uneven heating/cooling. | Reactors, heat exchangers, mixers (with heating/ cooling). |
| 3 | Use seals to avoid evaporative losses | Vapours and steam escape contribute to material and energy losses and should be avoided. | All equipment and pipes. |
| 4 | Plant purchasing criteria to include energy efficiency. | During design stage and procurement, energy efficiency should be considered as well for opportunities in savings on energy cost. | All equipment especially pumps, motors and lights. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 5 | Consolidate loads to reduce deliveries. | Proper logistical planning will avoid unnecessary trips to save on fuel costs. | Material handling, conveying systems, storage and transport facilities. |
| 6 | Position plant to reduce transport to markets. | During design stage the distance which a product or material need to travel should be considered to minimise transport and handling requirements. | All new plants. |
| 7 | Maintain fleets to reduce pollution and improve fuel efficiency. | A well maintained vehicle will reduce possibilities of breakdowns and excessive fuel consumption. | Transport vehicles, lorries and forklifts. |
| 8 | Attempt to improve load factor and efficiency by operating as near as possible to the designed rating. | Most equipment is most efficient at the designed rating. | Boilers, heaters, furnace, pumps, and motors. |
| 9 | Operate boilers at designed pressure. | Boilers operate at their peak efficiency when they operate at the designed pressure. | Boilers. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 10 | Make sure combustion is complete. If not, check for: -Flame impingement; -Inadequate air-fuel mixing; -Inadequate atomization; and -Inadequate air for combustion. | Incomplete combustion will consume excessive fuel unnecessarily and energy losses can be very large. | Furnaces and boilers. |
| 11 | Avoid letting excessive fuel moisture enter the burner. | Evaporation of water absorbs considerable amounts of heat and consumes fuel unnecessarily. | Furnaces and boilers. |
| 12 | Seal all cracks and holes in boiler flues to prevent air infiltration. | Air infiltration will affect boiler efficiency and damage the boiler. | Boiler. |
| 13 | Thoroughly clean tubes and other fire side heat exchange surfaces, at regular intervals. | Deposits will rapidly reduce heat transfer efficiently and quickly degrade the tubes. | Heat exchangers and boilers. |
| 14 | Investigate whether direct heating of any process is cheaper than steam heating. | Direct heating, eliminates the inefficiency of converting primary energy to steam. | Equipment which require heating (i.e. reactors, mixing vessels). |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 15 | Ensure that the refrigeration system is operating at the optimum design condition. Operate at the lowest condensing temperature and the highest evaporating temperature. | Un-optimised operation of refrigeration will consume excessive amount of energy. | HVAC, cold rooms and chilled water facility. |
| 16 | Ensure that the effective heat exchange surfaces are clean. | Deposits on effective heat exchange surface will affect the heat transfer coefficient and efficiency. | Condensers and heat exchangers. |
| 17 | Defrost fan coil units at regular intervals. | Frost build-up on coils hinder air movement and decrease cooling efficiency. | Chilled-rooms, freezers and chilled water plant. |
| 18 | Clean heat exchanger surfaces regularly. | Deposit built-up on effective exchange surfaces change the overall heat transfer coefficient and decrease efficiency. | Heat exchanger, boilers and furnaces. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 19 | Log fuel consumption data on vehicles. | Transport vehicles consume a lot of fuel. By keeping a log on fuel consumption, any changes can be identified (i.e. due to maintenance required for vehicles). | Transport vehicles, lorries and forklifts. |
| 20 | Carry out regular maintenance. | Generally, most equipment require some form of maintenance at specific recommended times. This will ensure all parts work efficiently and are subject to minimal wear and tear. | All equipment and vehicles. |
| 21 | Motivate drivers to maintain proper speed limits. | Exceeding speed limits increases risk of accidents and decreases fuel efficiency. | Transport vehicles, lorries and forklifts. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 22 | Inflate tyres to recommended pressure. | Insufficient and excessive inflation of tires will increase fuel consumption, increase risk of accident and increase wear on tyres. | Transport vehicles, lorries and forklifts |
| 23 | Prevent fuel spillage during re-fuelling. | Spillage can occur during re-fuelling due to improper handling. This can be caused my insufficient training of personnel. | Transport vehicles, lorries and forklifts |

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Chapter

# 10

# CP Tips for Water Saving at a Premise

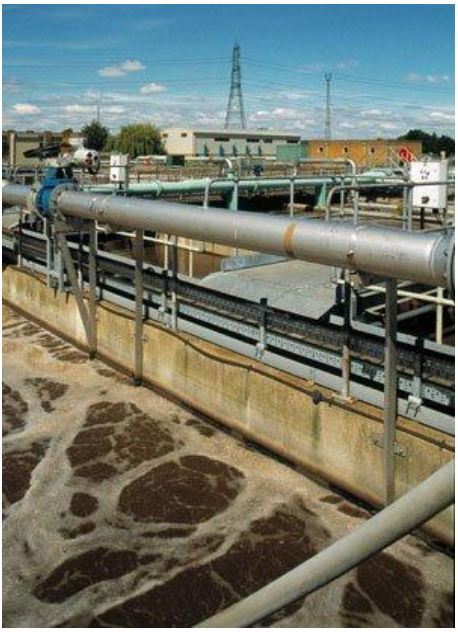
## 10.1 Detail option

**TIPS 1/ WATER**

| | | |
|---|---|---|
| Option | : | Recycle/reuse water. |
| Description | : | In many premises, large amount of water is being used for processes and cleaning activities which directly contributes to wastewater generation. By recycling the used water, the net amount of water used can be reduced. |
| Application | : | All process streams involving water usage. |
| Outcomes | : | Reduce direct cost of water.<br>Reduce wastewater generation and therefore reduce treatment cost. |
| Methodology | : | Reuse water from "cleaner" stages of production in "dirtier" stages of the next production cycle. Recycled water may or may not require treatment before use. For example, use rinse water from the final stage of production for the initial soaking or washing of the next batch of raw material. |

| | | |
|---|---|---|
| Tips | : | Sometime water used in the processes may be still clean and can be used for cleaning purposes (cleaning floor or any non-critical areas) even without going through the treatment process. |
| Category of option | : | Moderate to large amount of investment required. Return normally within 1-2 years. |
| Financial consideration | : | Recycling facilities can be costly. |

**Pictures /diagram**



*Wastewater generation can reach massive volumes if not controlled. Image shows a WWTP*

| | | |
|---|---|---|
| Other relevant information | : | Recycling water into the production area may require pre water treatment to avoid contamination. |

**TIPS 2/ WATER**

| | | |
|---|---|---|
| Option | : | Use of smaller pipe for washing. |
| Description | : | Smaller pipes lower the water flow rate and therefore lower water consumption compared to bigger size pipes. Smaller pipes also produce higher velocity and could be ideal for washing activities. |
| Application | : | Washing / cleaning activities. |
| Outcomes | : | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| Methodology | : | Identify and replace current (big) pipes with smaller ones. The pipes should also be fitted with a control valve to avoid higher water wastage. |
| Tips | : | 1-2 inch diameter pipes are suitable for this purpose. |
| Category of option | : | Small investment required. Return can be expected within 6 months. |

**Pictures /diagram**

*Smaller hoses may be affixed to pipes used for washing to reduce flowatre*

**TIPS 3/ WATER**

| | | |
|---|---|---|
| Option | : | Fix hand triggers to hoses. |
| Description | : | Using hand triggers (normally closed type) will prevent water wastages through unclosed valve. |
| Application | : | Washing / cleaning activities. |
| Outcomes | : | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| Methodology | : | Triggers can be installed at water hose to control water flow and pressure. |
| Tips | : | Many types are available and cost below RM 100. |
| Category of option | : | Minimum investment required. Return normally within 6 months. |

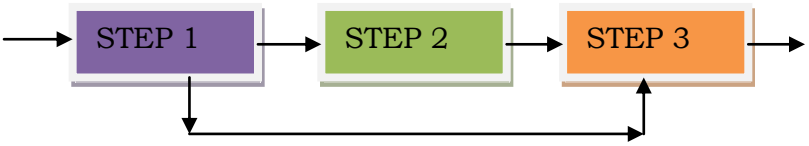
**Pictures /diagram**

*Typical hand triggers can be attached to hoses.*

**TIPS 4/ WATER**

| | | |
|---|---|---|
| Option | : | Eliminate steps (where possible). |
| Description | : | Processing steps need to be re-examined for its necessity. Reducing or eliminating steps that consumes water will directly reduce overall water consumption. Elimination of steps is the highest level of CP implementation. |
| Application | : | Unnecessary steps (i.e. repeated cleaning steps). |
| Outcomes | : | Increase productivity and may even reduce energy usage. |
| | | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| Methodology | : | Implementation of this option requires a detailed study to determine its effect on product quality. |
| Category of option | : | Moderate investment required for modifications to process system (if applicable). |

**Pictures /diagram**




*If Step 2 is eliminated, the process is reduced from having 3 steps to 2 steps.*

| | | |
|---|---|---|
| Example | : | A vermicelli plant that requires three stages of washing for raw rice eliminated one washing step and the washing objective can still be met. |

**TIPS 5/ WATER**

| | | |
|---|---|---|
| Option | : | Optimize washing time/number of cycle. |
| Description | : | In many premises, washing/cleaning activities are done without prior detail study on time and cycles required to achieve the required results/objective. Therefore, optimizing time and number of cycles for washing/cleaning may reduce the water usage significantly. |
| Application | : | Washing/cleaning activities. |
| Outcomes | : | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| | | Increase productivity (faster time). |
| | | Reduce energy usage and may even reduce material lost. |
| Methodology | : | A detailed study on the effect on product quality is required before any changes can be made to process. |
| Category of option | : | Small amount of investment required to conduct the study. Medium to large amount of investment for modifications to equipment (if necessary). |
| Example | : | 400 kg of meat was rinsed three times and each rinsing takes about five minutes. The total water used and wastewater generated is about 2 $m^3$. By reducing the duration of the rinsing or number of cycles, the total water used can be reduced significantly. |

**TIPS 6/ WATER**

| | | |
|---|---|---|
| Option | : | Use pressure washing system. |
| Description | : | By using pressure system, the washing activities, especially washing of floors, drains and machines can be more efficient and use lesser amount of water. |
| Application | : | Cleaning and washing. |
| Outcomes | : | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| | | Increase productivity (i.e. faster time to wash). |
| | | Reduce energy usage and may even reduce material lost. |
| | | Possible to achieve high quality of washing. |
| Methodology | : | Pressurised water system can be generated using a pressure pump or through a centralized system where probably water at about 3-6 bar pressure is required. |
| Category of option | : | For centralized washing system moderate amount of investment may be required. Return between 1-2 years. |

**Pictures /diagram**

*A typical pressure washing system.*

**TIPS 7/ WATER**

| | | |
|---|---|---|
| Option | : | Use of rain water. |
| Description | : | Initiatives should be taken to harvest the rain water if it is possible. The harvested rain can be used for non-process related activities. |
| Application | : | Perimeter washing.<br>General water usage (i.e. watering plant, cistern). |
| Outcomes | : | Reduce town water consumption. |
| | | Reduce direct cost of water. |
| | | By using rain water for some portion of the washing and cleaning, one can expect environmental benefit where carbon foot print related to producing town water can be reduced. |
| Methodology | : | Rain water can be harvested and collected into a tank with installed pipelines. Treatment may be required for certain applications but in most applications rainwater is only considered for applications that do not require it to be treated further. |
| Category of option | : | Require moderate amount of investment but monetary return may be poor and may take more than six years to return the investment. This option should be considered for non-monetary returns (i.e. environmental reasons). |

**Pictures /diagram**

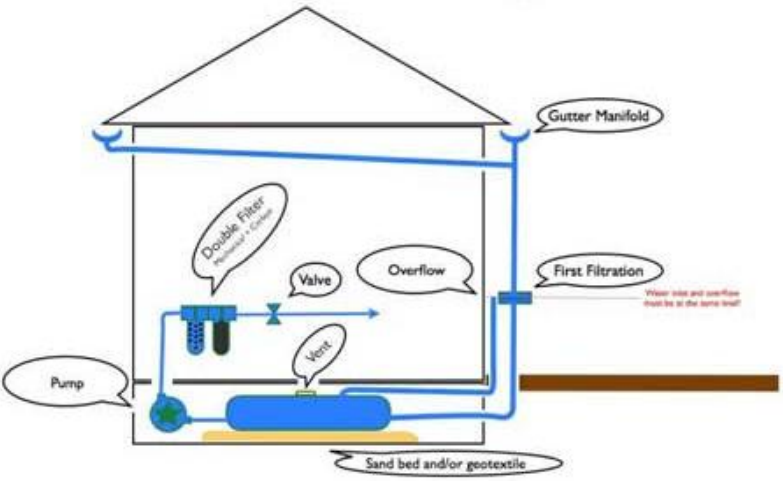



*Diagram above shows a typical rain collecting system. Rain is being harvested from the roof and gutter system. Collected rainwater passes to preliminary treatment which is the first filtration to remove any coarse materials before flowing into the tank for storage. Prior usage, the water is usually subject to secondary treatment which will consist of a filtration system, activated carbon filter and UV treatment depending on the intended use of the water.*

**TIPS 8/ WATER**

| | | |
|---|---|---|
| Option | : | Use automated washing. |
| Description | : | Manual washing (i.e. fruits, containers, and tanks) utilises excessive amount of water. Therefore, automated washing cycles create opportunities for savings and improved productivity because time, accuracy and of a wash cycle can be controlled and reproduced with great accuracy. |
| Application | : | Washing (i.e. equipment, tanks, vehicle). |
| Outcomes | : | Reduce direct cost of water. |
| | | Reduce wastewater generation and therefore reduce treatment cost. |
| | | Increase productivity (i.e. faster time to wash). |
| | | Reduce energy usage and may even reduce material lost (i.e. cleaning chemicals). |
| | | Possible to achieve high quality of washing |
| Methodology | : | Automated washing systems can be retrofitted into current premise with little or no modifications to existing facilities. |
| Category of option | : | Investment requirement ranges moderate to high depending on capacity. Return is dependent on the extent of the automation. |

**Pictures /diagram**

*Diagram on the left shows an automated cleaning system for transport trucks. Automation for washing saves a large amount of water and process time.*

**TIPS 9/ WATER**

| | | |
|---|---|---|
| Option | : | Use dry clean-up methods. |
| Description | : | Dry clean-ups methods can replace the common wash and rinse method which requires water. In most cases these methods involve physical activities (i.e. vibration, jet air stream). |
| Application | : | Cleaning activities (i.e. processing area, tanks, vehicles). |
| Outcomes | : | Reduce direct cost of water.<br>Reduce wastewater generation and therefore reduce treatment cost. |
| Methodology | : | Large applications may require some equipment installation (i.e. pneumatic vibrators, air compressors).<br>Simple applications involve common tool and appliance (i.e. brooms, air blowers, scraper). |
| Category of option | : | Investment range from low to moderate depending on equipment required. |

**Pictures /diagram**

*Diagram on the left shows a worker using sweeping a warehouse using an industrial sweeping broom. Similar equipment can also be used to clean up vehicles, equipment and lighting to replace water jets.*

### 10.2 General Options

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 1 | Installation of water flow meter and level indicator. | Flow meters and lever indicators will allow accurate measurements so proper controls can be made to supply only the designed amount of water. This will prevent any wastage and ensure process is running efficiently. | Whole process plant. |
| 2 | Improve washing efficiency through installation of flow restrictors to control water volumes, use counter current washing procedures. | Increased washing efficiency will increase productivity and reduce wastewater generation. | Washing processes/ activities. |
| 3 | Balance acid and alkaline waste water streams to neutral pH. | This will reduce loads to the wastewater treatment plant. | Wastewater treatment plant. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 4 | Ensure proper feed water treatment is carried out. | Incorrectly treated water will affect heat transfer, steam quality and plant life. | Boilers. |
| 5 | Keep flow down to minimum. | Flow down streams increase wastewater generation and is a source for heat loss. | Boilers. |
| 6 | Recover as much condensate as possible. | This substantially reduces feed water heating requirements and water treatment costs. | Boilers. |

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# Chapter 11

# CP Tips for Material Saving at a Premise

## 11.1 Detail option

**TIPS 1/ MATERIAL**

| | | |
|---|---|---|
| Option | : | Buy/sell in bulk. |
| Description | : | When items are bought or sold in bulk, the number of packaging materials and related logistics attached to it is reduced. |
| Application | : | Raw materials.<br>Feedstock. |
| Outcomes | : | Reduce direct cost. |
| | | Reduce solid waste generation (i.e. packaging material). |
| | | Reduce carbon footprint (i.e. contributed by transportation and handling activities). |
| Methodology | : | Negotiate with suppliers to supply raw material in bulk. Minor or moderate modifications may be required on current storage and handling facilities. |
| Category of option | : | Investment may be required if facilities need to be modified to cater for changes in handling and storage capacity. However, the return is typically within 1-3 years. |

**Pictures /diagram**

*A typical sight in a warehouse.*

| | | |
|---|---|---|
| Caution | : | Be careful not to overstock raw material (i.e. perishable materials). |

**TIPS 2/ MATERIAL**

| | | |
|---|---|---|
| Option | : | Buy recyclable products/materials. |
| Description | : | Used materials or resources are common contributors to waste generation in a facility (i.e. used packaging material, spent catalyst, residual material, solvents). Recyclable materials will reduce waste generation and create opportunities for cost saving. |
| Application | : | All raw materials.<br>Office and administrative materials (i.e. paper, printer toners).<br>Packaging materials. |
| Outcomes | : | Reduce waste generation. |
| | | Reduce material consumption. |
| | | Reduce material cost. |
| | | Eco-branding the product manufactured as an environmental friendly products. |
| Methodology | : | Sometimes a particular raw material (i.e. one which ends up as waste) can be substituted by a recyclable material by little or no modification to the process equipment. |
| Category of option | : | The financial implication for this option is dependent on type of material and modifications required. The cost and implications of recycling the material should also be taken into account. |

**Pictures /diagram**

*Scrap metal being collected for recycling.*

*Recycled paper in rolls.*

| | | |
|---|---|---|
| Other relevant information | : | A thorough study is required to determine appropriate material substitutes. Extra attention should be given to make sure product quality and productivity is not affected. |

**TIPS 3/ MATERIAL**

| | | |
|---|---|---|
| Option | : | Practise First in First Out (FIFO). |
| Description | : | The basic principle of FIFO is preventing materials from being stocked up for periods longer than is absolutely necessary. It is a combination of systematic management of logistics and inventory. |
| Application | : | Storage area and facilities. |
| Outcomes | : | Reduce waste generation (i.e. materials exceeding shelf life). |
| | | Reduce unnecessary product handling. |
| Methodology | : | FIFO systems may require some racking system and/or modifications to current storage facility. |
| Category of option | : | The cost implications may vary but range from low to medium capital investment. |

**Pictures /diagram**

*Aa FIFO system being employed in a warehouse.*

*A shelving/racking system designed for FIFO applications*

**TIPS 4/ MATERIAL**

| | | |
|---|---|---|
| Option | : | Use less toxic material. |
| Description | : | Many products with lesser toxicity level are being manufactured in recent times. This includes solvents (water based compared to solvent based) and herbal based cleaning materials. Premises are advised to evaluate the toxicity of their chemicals, cleaning materials, additives and other laboratory chemicals. In the market, there could be a substitute which could be an attractive alternative for an existing chemical. |
| Application | : | Chemicals, cleaning agents. |
| Outcomes | : | Reduce toxicity of material. |
| | | Reduce health risk/reduce schedule waste generation. |
| | | Environmental friendly product and reduction in disposal cost due to lesser generation of toxic waste. It is also good for the safety of the operators. |
| Methodology | : | Less toxic materials (i.e. raw material, cleaning chemicals) can replace existing chemicals with or without modifications to process parameters or equipment involved. |
| Category of option | : | The costs are very much dependent on the type of material being substituted. |

**Pictures /diagram**

*Natural based products like soaps and detergents are available in the market.*

**TIPS 5/ MATERIAL**

| | | |
|---|---|---|
| Option | : | Waste to wealth concept application. |
| Description | : | In a typical industry there could be many types of waste generated. Wastes were normally considered as nuisance in the past and are normally disposed off. With the advance technology and appreciation for the environment, many resource recovery technologies and methods are currently available. From making biodiesel from fat to making bricks using sludge, affordable technologies are now available. In fact the wastes are being bought for a fee by many parties for resource recovery purposes. The premise should take effort to turn their waste into wealth as well. |
| Application | : | Wastewater treatment sludge, packaging material, process waste, unused parts and even rejected raw materials and products. |
| Outcomes | : | Reduce overall waste generation. |
| | | Reduce treatment and disposal cost. |
| | | Reduce waste generation and profit by selling the waste for resource recovery. |
| Methodology | : | Detail study need to be conducted on possible uses of waste. |
| Category of option | : | No investment required if the resource recovery is conducted by third party. |

**Pictures /diagram**

*Waste material around the premise can be considered for other usage or purpose.*

### 11.2. General Options

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 1 | Check the need of each raw material. | Sometimes a particular material (especially those that end up as waste) can be reduced or eliminated by modifying the process. | Whole premise |
| 2 | Change shipping containers. | Containers and packaging material end up as waste. Attention should be given to reuse packaging material or minimise use on unusable ones. | All packaging materials. |
| 3 | Use inhibitors. | Side reactions can occur in reactors causing generation of off-spec products and by-products. Inhibitors can prevent unwanted side reactions or polymer formation. | Reactors. |
| 4 | Improve quality of feed. | Impurities in raw materials can contribute to waste generation. Purity of material can be achieved by working with the suppliers of the raw material or installing purification equipment on-site. | Reactors and mixers. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 5 | Recover product/ material from transport vehicle. | Spillage or residual material on transport material contributes to waste generation and wastage. | Transport vehicles and storage facilities. |
| 6 | Reduce number and quantity of samples. | Certain plants collect and catalogue samples from each batch of production. The number and quantity of these samples should be kept at minimum to achieve its objectives (i.e. quality monitoring). | All process lines. |
| 7 | Use seal-less pumps. | Seal-less pumps (i.e. magnetically driven pumps) reduce possibility leaks and losses. | Pumps. |
| 8 | Recover purges and seal flushes. | Flushes should be considered for recycling to the process to reduce waste generation. | All process lines. |
| 9 | Use on-line cleaning techniques. | On-line cleaning techniques (i.e. reversing brushes or circulating sponge balls) reduces equipment maintenance. | Pumping systems |
| 10 | Just in time and/or Do not overstock. | Overstocking can contribute to waste generation due to exceeding shelf life. Supplies should be maintained at optimal level at all times. | Storage facilities. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 11 | Cogenerate from waste. | Some waste products may be considered as fuel to generate energy (i.e. boilers). | Waste materials. |
| 12 | Recover/ Reuse off-spec product and/or by-product. | All waste streams/products should be examined for opportunities to recovery or reuse to reduce waste generation. | All waste and off-spec products. |
| 13 | Buy concentrate items compared with dilute items. | Concentrate items are less voluminous and reduce handling requirements. | Raw materials. |
| 14 | Reduce or eliminate "high waste cost" products. | Products that generate less waste should be considered to replace products that generate more waste. | All products. |
| 15 | Improve turn around and produce products when required. (lower stocks for warehousing) | Logistics and demand should be studied to avoid overproducing and overstocking products. Storage of products can consume resources (i.e. chilled facilities). | Products and process lines. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 16 | Order raw materials that are easier to handle and do not degenerate easily. | Alternative raw materials that is more robust reduce handling costs should be considered. | Raw materials. |
| 17 | Negotiate with suppliers to take back surplus and defective materials. | This will reduce waste generation and storage requirements. | Raw materials. |
| 18 | Negotiate the use of reusable packaging systems. | Reusing packaging material will reduce waste generation and direct packaging cost. | Raw material and product packaging. |
| 19 | Regenerate raw materials where possible. | Some raw materials can be treated or regenerated so it can be reused in the process or other auxiliary processes. | Raw material. |
| 20 | Controls on bulk tanks to avoid overflows. | All tanks should have overflow control to prevent losses. | Tanks. |
| 21 | Checks on material weights to conform to orders. | Material quantity and quality should be logged for discrepancies and quality control. | All material. |
| 22 | Bund liquid tanks to contain spillage. | Spilled material can upset waste treatments plants and should be contained (i.e. for specific treatment or disposal). | Tanks and vessels. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 23 | Use tanks that will fully drain. | Tanks should be designed to fully drain to avoid residual losses. | Tanks and vessels. |
| 24 | Minimize the number of times materials are moved on site. | Proper logistics design avoids unnecessary handling steps which consume time and resources. | Materials and material storage. |
| 25 | Check transfer lines regularly for leaks and spills. | Properly maintained lines and equipment eliminate possibilities of losses due to leakages. | All process lines and equipment. |
| 26 | Rinsing should be done with minimal water volumes. | Optimising standard operating procedures for cleaning should be carried out to reduce water consumption. | Cleaning and draining of equipment and lines. |
| 27 | Reuse packaging systems. | Consider using reusable packaging systems (i.e. wooden crates instead of boxes). | Packaging. |

# Chapter 12

# General CP Options

CP option implementation is largely dependent on the support system as well. The training for the staff, maintenance and general housekeeping items must be given sufficient attention as well. Some tips are as follows:

**(a) Training & Incentives**

- Make employees aware of the reasons for waste reduction.
- Train all employees on the principles of Cleaner Production.
- Provide incentives for cleaner working practices.
- Provide opportunities for suggestions to be registered with management.

**(b) Housekeeping**

- Reuse paper binders to reduce stationery consumption.
- Use refillable pens, pencils and other office equipment.
- Paper reduction through more effective use (less reports, less copies, use the complete page, better quality control, reduce form work, reduce financial reports, print changes only, use both sides of paper).

- Use 5S[1] to keep working area clean and in order.
- Use Kaizen[2] to improve the premise continuously.
- Do not mix the different type of waste generated.

**(c) Maintenance**

- Maintain equipment according to schedule.
- Maintain all maintenance records to follow trends and changes in conditions.
- Regularly calibrate all instruments. Instruments quickly become inaccurate if not regularly calibrated.
- Ensure boiler sundry equipment is regularly maintained.

[1] 5S is the name of a workplace organization methodology that uses a list of five Japanese words which are *seiri, seiton, seiso, seiketsu and shitsuke*. There are 5 primary phases of 5S: sorting, straightening, systematic cleaning, standardizing, and sustaining. *(source: Wikipedia)*

[2] Kaizen (改善), Japanese for "improvement" or "change for the better", refers to philosophy or practices that focus upon continuous improvement of processes in manufacturing, engineering, supporting business processes, and management. *(source: Wikipedia)*

## 12.1 Other General CP Options for Saving

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 1 | Use waste stream from other plants (i.e. industrial ecology). | Within a group of industries (i.e. technology parks) the quantity and quality of each plant's waste stream should be documented which can be reviewed by all plants in that group or vicinity to determine if any are suitable feedstock. | Group of industries. |
| 2 | Program plant to handle unexpected upset and trip. | Trips and process upsets cannot be avoided altogether. Processes should be designed (i.e. controlled) to respond to these upsets to reduce or eliminate losses (i.e. spillage, runaway reactions, equipment damage). | All process lines. |
| 3 | Automate start-ups, shutdowns and product changeover. | Designing and programming a process line to reach stable operating condition as quick as possible after start-ups, shutdowns and product changeover will time generating off-spec products (i.e. which end up as waste). Furthermore, equipment damage, wear and fouling can be reduced. | All process lines. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 4 | Use non-corroding tubes. | Non-corroding tubes foul much slower and reduce waste generation (i.e. off-spec products). | Heat exchangers, boilers and reactors. |
| 5 | Improve control system. | A good control system is important to reduce generation of off-spec products and side-reactions. | All process lines. |
| 6 | Improve catalyst. | Many new and improved catalysts are available in the market with new features (i.e. reduce waste generation or improved activity). | Reactors. |
| 7 | Improve mixing efficiency. | Improper mixing or inadequate mixing can be the cause of off-spec product generation. Attention should be given to improve mixing by new impeller design or vessel design. | Reactors and mixers. |
| 8 | Reduce levels of reprocessing. | Unnecessary processing consumes resources and generates waste and should be avoided or minimised. | Washing processes and other processes. |
| 9 | Eliminate chemical additions where possible. | All materials should be re-examined to determine its need and possibility for reduction or elimination. | All material. |

| No. | Options | Description of CP Benefits | Application |
|---|---|---|---|
| 10 | Examine opportunities to reduce chemical consumption. | Sometimes, less material can be consumed by modifying equipment or optimising process parameters. | Processes. |
| 11 | Replace chemicals with a "high environmental impact" with chemicals with a "low environmental impact". | Alternative (more environmental friendly) materials are being developed and should be considered to replace current ones. | All material. |
| 12 | Replace inorganic acids and alkalis with organic acids and alkalis where possible. | Organic material is more bio-degradable compared to inorganic materials. | All material. |
| 13 | Use highly bio-degradable chemicals. | Reduce generation of untreatable waste. | All materials. |
| 14 | Replace chemical attack with water pressure, or heat for cleaning. | Cleaning or washing using chemicals (i.e. detergents or oxidants) should be considered to be replaced with water supplemented with physical attack (i.e. pressure, sonication or scraping and brushing). | All cleaning, rinsing and draining processes. |


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