# GUIDELINES FOR
# GREEN INDUSTRY AUDITOR

JABATAN ALAM SEKITAR MALAYSIA

# GUIDELINES FOR
# GREEN INDUSTRY AUDITOR



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# FOREWARD

In support of the Government of Malaysia's effort to promote a green lifestyle and practices in Malaysia, the Department of Environment (DOE) is committed to promote and enhance Green Industry Practices, especially among the Small and Medium Enterprises (SMEs). Numerous programmes had been designed and implemented since the Ninth Malaysia Plan and sustained well into the Tenth Malaysia Plan.

One of the tasks undertaken was to create Qualified Green Industry Auditors whom will provide technical and advisory services to the industries in the implementation of these green industry initiatives. These Qualified Green Industry Auditors, comprising of DOE Officers, consultants, industry players and academicians will conduct audits and as a result identify opportunities in process quality, product and services enhancements to be furthered by the relevant industry or business entity.

On that note, this publication of Guidelines for Green Industry Auditors will not only serve as a reference and guidance document to the auditors but also a valuable reference to the DOE enforcement personnel.

At its core, this guide outlines among others, the do's and don'ts during the performance of an audit. Hence, I hope that this guideline will not only streamline the planning and execution of green industry auditing, but also facilitate the adoption and implementation of green industry practices by the industries in Malaysia.

**DATO' HALIMAH HASSAN**
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# 1. INTRODUCTION

Environmental conservation and sustainable development have become a global effort over the past two decades. A green and environmentally friendly business should not only comply to rules and regulations but should also be energy efficient with minimal waste generation and processes. In order to remain competitive, industries have to be more creative in reducing resource consumption, increasing process efficiency, preventing waste generation and ultimately reducing carbon footprint.

Industries play an irreplaceable role in the country's quest to become a developed nation by 2020. In spite of their indispensable financial contribution to the country's wellbeing, their impacts on the environment are significant, building on the augmenting figures and facts of global warming and climate change. Industrial activities are unquestionably the main causes of greenhouse gases emission that is the culprit of rising global temperature. Moreover, inefficient industrial processes that often over exploit natural resources and adopt direct disposal method without a second thought on waste reclamation or resources reduction exaggerate the already worsening environmental condition. Industries, which only take care of their backyards and profits will no longer be competitive at the global stage in the long run, if they are to sustain.

Green Industry (GI) is an important strategy for sustainable development. It focuses on process optimization, cost saving, higher business return and higher compliance to environmental laws and regulations. GI is a preventive strategy aiming at minimizing the negative impacts of manufacturing process and products on the environment. As compared to the end-of-pipe treatment, GI based techniques and technologies use energy, raw materials and by-products more effectively. They reduce waste and hazardous waste generation, encourage reuse and recycling of natural resources and promote systematic management of wastes. Therefore, GI implementation plays a role in raising the legal compliance level of a premise, especially to Environmental Quality Act 1974 (EQA 1974). Besides, GI strategies also significantly benefit a premise both financially and environmentally at a global level.

In short, GI strategy aims at reducing global greenhouse gases emissions to mitigate climate change. It is in line with the statement made by the Malaysian Prime Minister at the United Nations Climate Change Conference at Copenhagen in 2009, that Malaysia would reduce carbon intensity by 40% by 2020 compared to its carbon intensity in 2005.

As a side-line to GI, carbon tax, which is a form of carbon taxing levied on carbon content of fuels can tactfully help the nation achieve the carbon reduction goal. As implemented in some of the technology savvy Asian countries such as China, South Korea and Japan or European countries such as Denmark, France and Sweden, carbon tax spurs a significant move within these countries towards lower carbon emission. The beauty and efficiency of carbon tax lie within its price-based execution. Economists have generally agreed that prices are the most powerful tool to guide market decisions. In other words, carbon tax can potentially reduce carbon emission of a nation by affecting consumers' choice of fuel, especially in a developing country like Malaysia where the number of registered cars and motorcycles increased by 2 million and 1.9 million respectively between 2005 -2009.

## 2. SCOPE

This guideline covers the general principles and information of GI implementation in a manufacturing or servicing premise. Each GI implementation stage, including planning, auditing, prioritization, implementation and performance monitoring of different GI options, is explained. It can be a reference for consultants or environmental practitioners who provide services to industries in Malaysia, particularly SMEs towards higher compliance level to Environmental Quality Act 1974 in all aspects, which include wastewater, solid waste, scheduled waste, emissions and workplace safety. Moreover, GI strategy also reduces carbon emissions.

This guideline can be used as an individual or additional reference to the existing industrial standards for a manufacturing industry. If the information in this guideline is different from the specific requirements of any applicable industrial standards, the industrial standard should be adopted.

## 3. TERMINOLOGIES

The following terms are used in this guideline:

**Auditing methodology** – Information collection process during the green industry audit.

**Auditing objective** – The objectives of green industry audit.

**Auditing scope** – Aspects, areas or processes that are included/ investigated in the green industry audit.

**Basis entity** – Used or generated components, which contribute to $CO_2e$ emission, including electricity, water, fuel, solid wastes and wastewater.

**Benchmark** – A reference point against which performance of a premise in terms of $CO_2e$ production is compared.

**Boundary** – An area within which green industry audit is conducted.

**Carbon footprint** – measurement of greenhouse gas emissions associated with the life cycles of individuals, processes or products to describe their impacts on the environment (often related to climate change).

**Cleaner Production** – A strategy for continuous $CO_2e$ reduction at a premise.

**$CO_2e$** – Known as total carbon dioxide equivalent. It is the total carbon dioxide emissions of a mixture of greenhouse gases.

**$CO_2e$ calculation** – Estimation of total $CO_2e$ emission from all entities of a premise for a manufacturing process within a fixed boundary.

**$CO_2e$ emission of a manufacturing process** – Total carbon dioxide equivalent emission of a premise for a manufacturing process within a fixed boundary.

**$CO_2e$ reduction** – Reduction of total carbon dioxide equivalent emission of a premise through green industry practice for a manufacturing process within a fixed boundary.

**Emission factor / Carbon emission factor / CEF** – Multiplying factor for measurement of greenhouse gases emissions of an entity.

**EQA 1974** – Environmental Quality Act 1974.

**Green Industry (GI)**– An industry that is committed to environmental management through prevention, reduction or minimization of resources consumption and waste generation in its manufacturing process and services towards carbon dioxide equivalent emission reduction for sustainable environment.

**Green Industry Audit (GIA)** – Information collection and analysis process to identify opportunities for green industry implementation.

**DOE Green Industry Auditor** – DOE officers who are competent in green industry audit.

**Green Industry Auditor** – Individual who has passed the certification assessment and registered with DOE as a green industry auditor.

**Green Industry Options (GI options)** – Efforts/ methods/ suggestions for $CO_2e$ reduction at a premise.

**Green Industry pre-audit** – Preliminary data collection through observation and identification of issues encountered by the premise.

**Greenhouse gases (GHG)** – Refers to gas elements in the atmosphere, which contribute to greenhouse effect or global warming. GHG includes carbon dioxide, methane, nitrous oxide, hydrocarbon, per-fluorocarbon and sulphur hexafluoride.

**GWP** – Known as Global Warming Potential. It refers to global heating potential of a GHG compared to carbon dioxide.

**Target Entity** – Entity that has the highest contribution percentage to $CO_2e$ production at a premise and the highest potential to be improved.

**IETS** – Industrial Effluent Treatment System.

**IPCC** – Intergovernmental Panel on Climate Change.

**Issue** – Aspects at a premise, which have been identified to contribute to carbon dioxide emission.

**Losses** – Lost resources that cannot be reclaimed technically.

**Premise** – Manufacturing areas, which include processing, storage, administrative and industrial effluent treatment areas.

**Ranking** – Prioritization process of proposed GI options.

**Standard** – A document that explains principles and requirements for achieving a certification.

**SME** – Small and Medium Enterprise.

**Wastage** – Unnecessary / excessive use of materials.

## 4. THE NEED FOR GREEN INDUSTRY FOR MANUFACTURING PREMISES

This guideline is established specifically for manufacturing industries in Malaysia to implement Green Industry at their premises. It can be used as reference by consultants or environmental practitioners who provide services to businesses wishing to implement Green Industry strategy at their premises.

This guideline presents a collection of simple Green Industry strategies with quick wins that can be implemented at a premise. Such strategies are often associated with reduction of $CO_2e$, focusing on the entities that contribute to greenhouse gases emissions, which will directly contribute to $CO_2e$ reduction at the premise.

Green Industry implementation will also facilitate establishment of manufacturing premises that are clean, efficient and with high productivity by engaging operating procedures that are more environmentally friendly.

## 5. INTRODUCTION TO THE CARBON DIOXIDE EQUIVALENT CONCEPT FOR GREEN INDUSTRY

The $CO_2e$ used in GI should not be confused with carbon footprint. While $CO_2e$ is used interchangeably with carbon emission, it should be clear what each term represents. Carbon footprint for a product or process usually represents the collective emissions of GHG accounted for the entire life cycle. This includes manufacture, transport, use, reuse (or recycle) and ultimate disposal of the products and its by-products. The term $CO_2e$ has been introduced to represent the carbon emission (or GHG) contributed by activities within the premise. In other words, the boundary is set by the premise's gates. Depending on the case, there are instances where the emissions arising from transport is also considered. The boundaries should be clearly defined in the GIA Scope.

The $CO_2e$ concept is specifically developed to assess the current performance of the premise (benchmark against standards or best in class) and subsequent GI option performance monitoring (self benchmarking).

## 6. HOW TO USE THE GUIDELINE FOR GREEN INDUSTRY AUDITOR

This guideline is designed for users with different expertise and level of experience. It can be used to prepare GI strategy implementation plan according to the implementation stages. Department of Environment (DOE), Malaysia has established a standard for GI auditing, evaluation, and monitoring and report preparation process. This guideline fulfils the requirements by DOE in raising the legal compliance level among the industries to EQA 1974 through GI implementation.

A structured and organised framework is required for GI implementation. It is essential to make sure that the collected information is complete. 6 phases of GI implementation is described in this guideline:

| | | |
|---|---|---|
| Phase I | : | Planning |
| Phase II | : | Green Industry Audit |
| Phase III | : | Generation of Green Industry Audit |
| Phase IV | : | Evaluation of Return of Green Industry Options |
| Phase V | : | Implementation and Monitoring |
| Phase VI | : | Continuous Improvement |

## 7. THE DO'S AND DON'TS

The implementation of any Green Industry initiatives at a premise can involve many stakeholders from within or outside the company. GI auditor will collect, document, analyse and report information that may be sensitive or even confidential before, during and after the audit process. The basic philosophy underlining the audit process is to gather useful information that will help improve the premise. The following do's-and-don'ts list is not exhaustive but provide an overall perspective of the qualities and traits a GI auditor should possess.

The do's of GI audit:

- ✓ The GI Auditor should stay focused on the objective and scope of the audit.
- ✓ The schedule for the whole process should be observed.
- ✓ The GI Auditor should knowledgably be aware of existing issues at the premise.
- ✓ Any pre-perceived conceptions, especially negative ones, should be avoided at all times.
- ✓ Take time to clearly explain the objectives, scopes, activities and targeted outcomes of the whole process to all the stakeholders involved.
- ✓ Adhere to all the rules and guidelines at the premises.
- ✓ Be an avid listener.
- ✓ Use attentive body language.
- ✓ Gather information that is required only.
- ✓ Respect confidentiality of the obtained information. Seek permission and clarification if there are any uncertainties.

The don'ts of GI audit:

- ✓ Avoid being insistent in any matter.
- ✓ Avoid bossing around.
- ✓ Never question the integrity of the premise operators.
- ✓ Do not expect special treatment from the premise operators.
- ✓ Do not ask for confidential information.
- ✓ Avoid comparing any aspect of the operation or facilities with other premises.
- ✓ Avoid being argumentative.
- ✓ Avoid discussing sensitive issues.

# 8. PHASE I: PLANNING

## 8.1 PRE-AUDIT (QUALITATIVE ASSESSMENT)

Pre-audit is conducted to collect the preliminary and background information of the premise that is to be audited. Information on manufacturing process and all activities at the premise are the main information that should be collected. This information serves as the basic for determining the focus and depth of the audit.

Most of the time, pre-audit is conducted through walkthrough activity. Table 8.1 provides an overall explanation on the walkthrough process. The checklist for the walkthrough process can be used as a guide for the auditors to identify the issues or main problems in the premise. An example of the checklist is provided in Appendix 1.

**Table 8.1: Walkthrough process checklist**

| ACTIVITY | : | WALKTHROUGH |
|---|---|---|
| Objectives | : | • Observe activities and processes at the premise<br>• Observe operating structures, management and size of the premise<br>• Identify and list the main issues encountered by the premise<br>• Identify suitable personnel to form a team responsible for GI implementation at the premise |
| Targeted areas | : | • Raw materials receiving process<br>• Raw materials storage (including chemicals)<br>• Administration<br>• Weighing of raw materials<br>• Main processing<br>• Auxiliary processing<br>• Packaging<br>• Waste storage (including hazardous wastes)<br>• Product storage<br>• Industrial effluent treatment system<br>• Quality laboratory<br>• Other facilities such as canteen, laundry areas and recycling areas |

| ACTIVITY | : | WALKTHROUGH |
|---|---|---|
| Implementation Methodology | : | • Observation |
| References | : | • Plant layout of the premise<br>• Process flow chart |
| Tools | | • Checklist<br>• (Refer to Appendix 1) |
| GI team members and functions | | • Owner or manager of the premise<br>• Manager has the knowledge about the main issues, capacities, direction and future plan of the premise. He or she can also gauge the willingness of the management to participate in the GI exercise.<br>• Production manager<br>• Production manager has the information on specific issues in processing and production. He or she also knows the capacity and production rate of the premise. |
| Outputs | : | • A list of the main issues of the premise<br>• Sources/ causes of wastage or loss of materials/ energy<br>• Sources/ types of safety risks<br>• Information collection strategies for the audit process<br>• Audit schedule (Refer to Appendix 2) |
| Tips | : | • Consider the entire premise<br>• Complete the pre-audit activities within ½ to 1 day (depending on size of premise)<br>• Involvement of the management team of the premise during the pre-audit activities is recommended |

## 8.2 AUDIT EQUIPMENT

Measuring devices are important for collecting information during the audit. The suitability of an audit equipment plays an important role in ensuring the data quality. Some of the factors that need to be considered are number of equipment required, accuracy of measurement, calibration of equipment and consumables that may be required. Some measurements require sampling and should adhere to the existing standard methods, where applicable.

**a) Temperature**

Temperature is one of the parameters that is the easiest to measure. There are many handheld devices to measure temperature based on the range and accuracy required. Non-contact thermometers are also available. One example is shown in Figure 8.2.1.


Figure 8.2.1: Infra-red Thermometer

**b) Electricity**

Electrical consumption can be expressed as kW.hr. It can be estimated through the power rating of the appliances. For example, an electrical motor rated at 1.5 kW will consume 1.5 x 2 kW:.hr energy if it is operated for two hours. Similarly, by knowing the rating of the electrical appliances and the total operating time, one can estimate total electrical power consumption. If the rating is not available, one can use a handheld wattmeter to determine the rating. One example is shown in Figure 8.2.2.

Figure 8.2.2: Handheld Wattmeter

**c) Colour**

Colour of wastewater can be quantified or measured using a colorimeter. This device quantifies colour by measuring the transmitted light through the wastewater and determines the concentration of a solute (for example, dye) in the wastewater. There are many types of colorimeters available in the market and Figure 8.2.3 shows one of the examples. This device can also be used to measure Chemical Oxygen Demand. Some brands offer disposable kits which are parameter specific.


Figure 8.2.3: Colorimeter

**d) Water Flow Rate**

The flow rate of wastewater is an important parameter to study for quantifying water consumption. High water flow rate may increase water consumption unnecessarily and cause problems such as water leakage or broken pipes. Water flow rate can be measured in different units such as litre/sec, $m^3$/sec, gallons/ min, etc. Commercial flow meters that are commonly used include Pygmy meter, vortex meter, flow probe and current meter. Figure 8.2.4 shows an example of flow meter.

Figure 8.2.4: Flow meter

**e) Data**

While real-time environmental data is important, recorded data for past operations are equally important. While most of the data are in electronic form, there are records that are only kept in hardcopies. Re-entering such data into computer is time consuming and ineffective. A solution to this problem is to use a handheld scanner, which is highly portable. It can be used to scan documents at ease and transform the data into electronic format that can be read in computer. Figure 8.2.5 shows an example of handheld scanner.


Figure 8.2.5: Handheld scanner

# 9. PHASE 2: GREEN INDUSTRY AUDIT

## 9.1 INFORMATION COLLECTION (QUANTITATIVE ASSESSMENT)

Green Industry Audit (GIA) is a data and information collection activity that helps in assessing the operation efficiency, providing information on whether the operating activities have positive or negative impacts on the environment. The collected information will be used to evaluate the performance of a company to identify areas for improvements. Such information will also help in identification of causes of problems/ issues and potentials for improvements. Table 9.1 shows a checklist that can be used to outline the audit process. Modifications can be made where necessary.

**Table 9.1: Audit process checklist**

| ACTIVITY | : | AUDITING |
|---|---|---|
| Objectives | : | Collect information to identify sources and measure the following aspects:<br>• Materials usage<br>• Energy usage<br>• Waste generation<br>• Risk level<br>• Productivity<br>• Product quality |
| Scopes | : | Auditing can focus on the following areas:<br>• Processing area<br>• Storage area of raw materials/ products/ wastes<br>• Entire premise<br>• Industrial effluent treatment system<br>• Administrative area<br>• Other facilities |
| Implementation Methodology | : | • Review of records<br>• Measurement<br>• Estimation<br>• Calculation<br>• Photographing and video filming |
| References | : | • Company profile<br>• Process flow chart<br>• Standard operating procedures<br>• Equipment specification<br>• Plant layout plan<br>• Material safety data sheet<br>• Records of products and raw materials<br>• Operating schedule<br>• Operating procedures<br>• Utilities bills |
| Tools | | • Audit form<br>(Appendix 3) |

| ACTIVITY | : | AUDITING |
|---|---|---|
| Tips | : | • Complete the activity according to the schedule<br>• Prepare the needed materials prior to the auditing activities<br>• Decide the unit/ rate that is to be used for relevant estimations/ calculations |

### 9.1.1 Raw Materials Receiving

Raw materials receiving is an important process for uninterrupted supply for manufacturing and product quality control. If the required quality for raw materials is not met, materials and energy usages may increase due to possible repetition of parts of the manufacturing processes or disposal of off-spec products. Diagram 9.1.1 illustrates the flow of inputs and outputs of the raw materials receiving process. Auditing should focus on quantification of the relevant materials flow and also the material loss due to handling or storage.

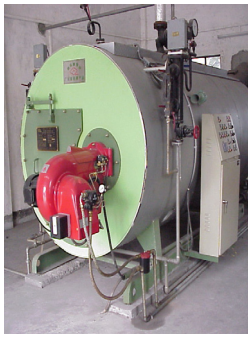
| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Raw materials<br>• Solid raw material (kg/month) (pcs./month) (pallet/month)<br>• Liquid raw material ($m^3$/month)<br>• Packaging materials (kg/month)<br>• Spare parts / consumables (kg/month)<br>2. Other materials<br>• Workshop supplies<br>• Fuel<br>• Etc. |  <br>Raw materials receiving | 1. Products<br>• Raw materials according to the process (kg/month)<br>2. Solid waste<br>• Packaging materials (kg/month)<br>3. Liquid waste<br>4. Gas emission (not likely)<br>5. Scheduled waste<br>• Packaging of chemicals<br>• Containers and bottles |

Diagram 9.1.1: Input – output flow of raw materials receiving process

### 9.1.2 Processing (Main and Auxiliary)

The following diagram illustrates the general input-and-output flow of a typical production process. Auditing should focus on quantification of the relevant materials flow. A detailed audit can be conducted by considering each unit operation, although in many cases an overall consideration of a process may be sufficient.

The audit may also be conducted separately for auxiliary processes, for example the clean-in-place (CIP) of the process line, replacement of consumables or even priming of the process line. Diagram 9.1.2 illustrates the flow of inputs and outputs of a typical production process or unit operation. Auditing should focus on quantification of the relevant material flow.

| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• *raw materials according to formula / specification (kg/month)<br>2. Energy<br>• Electricity (kW.hr/month) |  <br>Unit operation / process | 1. Products<br>• Main products (kg/month) (l/month)<br>• By-products (kg/month) (l/month)<br>2. Solid waste (kg/month)<br>3. Liquid waste<br>• Water for cleaning purpose ($m^3$/month)<br>4. Gas emission<br>5. Energy loss / heat loss / sound<br>6. Others |

*calculated based on specifications or monthly production rates

Diagram 9.1.2: Input – output flow of production process / unit operation

### 9.1.3 Packaging Process

Packaging is usually the last process before temporary storage and delivery of finished products. Diagram 9.1.3 illustrates the input-and-output flow of a typical packaging process. Auditing should focus on quantification of the relevant materials flow.

| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• Product (kg/month) (l/month)<br>• Packaging materials/ papers (kg/month)<br>• Boxes (kg/month)<br>• Pallets (no./month)<br>2. Energy<br>• Electricity (kW.hr/month)<br>3. Fuel<br>• Petrol/Diesel/ Natural gas (kg/month) |  <br>Packaging | 1. Products<br>• Packaged products<br>2. Solid wastes<br>• Packaging materials (kg/ month)<br>• Used pallets (kg/month)<br>3. Liquid wastes<br>4. Gas emission (not likely)<br>5. Others |

Diagram 9.1.3: Input – output of packaging process

### 9.1.4 Storage

Raw materials, wastes and products can be wasted if they are not stored properly. The following diagram provides a general view on the stored components and the possible wastes due to improper storage. Diagram 9.1.4 illustrates the input-and-output flow of a typical storage process. Auditing should focus on quantification of the relevant materials flow.

| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• Products<br>**Raw materials<br>**Packaging materials<br>• Pallets (no./month)<br>**Wastes<br>2. Energy<br>• Electricity (kW.hr/month)<br>3. Fuel<br>• Petrol/Diesel/Natural gas (kg/month) |  <br>Storage | 1. Solid wastes<br>• Spoiled/off-spec/excess products and samples (kg/month)<br>• Packaging materials (kg/month)<br>**Spoiled raw materials<br>2. Liquid wastes<br>3. Gas emission (not likely)<br>4. Others |

Diagram 9.1.4: Input – output of storage process

### 9.1.5 Industrial Effluent Treatment System

There are industrial effluent treatment systems for many manufacturing plants. The following diagram illustrates the input-and-output flow of the general treatment process. Diagram 9.1.5 illustrates the input-and-output flow of a typical wastewater treatment system. Auditing should focus on quantification of the relevant materials flow. The material flow may be slightly different between biological and chemical IETS.

| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• Wastewater ($m^3$/month)<br>• Chemicals (l/month) or (kg/month)<br>• Jumbo bags (no./month)<br>2. Energy<br>• Electricity (kW.hr/month) |  <br>Industrial Effluent Treatment System | 1. Products<br>• Treated wastewater ($m^3$/month)<br>2. Solid wastes<br>• Sludge (tonne/month)<br>• Chemicals containers (kg/month)<br>3. Liquid wastes<br>4. Gas emission<br>• Smell (cannot be measured easily)<br>5. Others |

Diagram 9.1.5: Input – output of storage process

### 9.1.6 Administrative Areas

Administrative areas can contribute significantly to energy usage in a manufacturing plant. Diagram 9.1.6 illustrates the input-and-output flow of the process. Auditing should focus on quantification of the relevant materials flow. Administrative work can contribute up to 30% of $CO_2e$ generation for selected small and medium enterprises (SMEs).

| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• Wastewater ($m^3$/month)<br>• Chemicals (l/month) or (kg/month)<br>• Jumbo bags (no./month)<br>2. Energy<br>• Electricity (kW.hr/month) | →  → | 1. Solid wastes<br>• Office wastes (kg/month)<br>2. Liquid wastes (none)<br>3. Gas emission (none)<br>4. Others (none) |
| | Administration | |

Diagram 9.1.6: Input – output of administration process

### 9.1.7 Other Facilities

Other facilities such as canteen, laundry, clinic, quality laboratory and maintenance workshops at the premise may utilize the same resources as the manufacturing processes such as water and electricity. Therefore, resources utilization at these facilities has to be considered. Diagram 9.1.7 illustrates the input-and-output flow of other relevant process at the premise. Auditing should focus on quantification of the relevant materials flow.

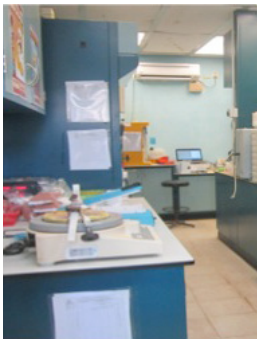
| INPUTS (RATE) | | OUTPUTS (RATE) |
|---|---|---|
| 1. Materials<br>• Water ($m^3$/month)<br>• Chemicals (Solvent) (l/month)<br>• Oil and grease (kg/month)<br>2. Energy<br>• Electricity (kW.hr/month)<br>3. Fuel<br>• LPG/Natural gas (kg/month) | →  → | 1. Solid wastes<br>• Used components<br>• Used machines<br>• Domestic wastes (canteen)<br>• Chemicals containers<br>2. Liquid wastes<br>• Waste oil (kg/month)<br>3. Gas emission<br>4. Others |
| | Laboratory | |

Diagram 9.1.7: Input – output of other processes

## 9.2 ESTIMATION OF CARBON DIOXIDE EQUIVALENT EMISSION FROM THE PREMISE AND TARGET ENTITY IDENTIFICATION

The targeted entities or hotpots can be identified based on the GI audit findings. The typical target entities are raw materials, water, electricity and fuel usage, as well as generation of solid wastes and wastewater. Besides, health risks and workplace safety are also always among the concerns. GI options can then be generated to mitigate or reduce the severity of the target entities. Target entities of a premise can be identified based on the quantity of carbon dioxide emission from materials usage and waste generation. Six main entities should be considered for quantification purpose, which include water, electricity and fuel usage; and generation of wastewater, solid wastes and hazardous wastes. The following formula is used to calculate carbon dioxide emission with the relevant carbon emission factors listed in the table below.

$$CO_2e(kg\ CO_2) = Carbon\ emission\ factor\left(\frac{kg\ CO_2}{unit\ entity}\right) x\ entity\ utilisation\ or\ rate\ (unit\ entity)$$

$$CO_2e(kg\ CO_2) = Carbon\ emission\ factor\left(\frac{kg\ CO_2}{unit\ entity}\right) x\ entity\ generation\ or\ rate\ (unit\ entity)$$

Unit:
$CO_2e$, Carbon dioxide equivalent emission: kg $CO_2$
Carbon emission factor(CEF): kg $CO_2$/ $unit_{entity}$
Utilization or production yield: $unit_{entity}$

Note: The values of carbon emission factor can be obtained from Intergovernmental Panel of Climate Change (IPCC). Some of the basic CEF values are given in Table 9.2.1.

**Table 9.2.1: Basic CEF values**

| RESOURCES UTILISED / WASTE PRODUCED | CEF | UNIT |
|---|---|---|
| Water [a] | 0.8 | kg $CO_2/m^3$ |
| Electricity [b] | 0.67 | kg $CO_2$/kW.hr |
| Fuel – LPG [c] | 1.53 | kg $CO_2$/litre |
| Solid waste [d] | 3.7 | kg $CO_2$/kg |
| Wastewater [e] | 1 | kg $CO_2$/kg COD removed |

Source


a. Cornejo, P. K., Santana, M. V. E., Hokanson, D. R., Mihelcic, J. R., & Zhang, Q. (2014). Carbon footprint of water reuse and desalination: a review of greenhouse gas emissions and estimation tools.
b. Association of Water and Energy Research Malaysia (2012) ENERGY EFFICIENCY IN MALAYSIA Sustainable Production and Consumption: Phasing-out Malaysia's Non-Energy Efficient Products, Malaysia: Association of Water and Energy Research Malaysia.
c. Intergovernmental Panel on Climate Change (2006) Guidelines for National Greenhouse Gas Inventories.
d. Murphy, J. D., & McKeogh, E. (2004). Technical, economic and environmental analysis of energy production from municipal solid waste. Renewable Energy, 29(7), 1043–1057.

e. Keller, J., & Hartley, K. (2003). Greenhouse gas production in wastewater treatment: process selection is the major factor. Water Science and Technology: A Journal of the International Association on Water Pollution Research, 47(12), 43–8.

Based on Table 9.2.2, the entity with the highest contribution percentage is considered as the target entity of the premise.

**Table 9.2.2: Example of $CO_2e$ analysis table for a premise**

| NO. | ENTITY | CARBON DIOXIDE EMISSION RATE | PERCENTAGE |
|---|---|---|---|
| 1 | Electricity | CEF (kg $CO_2$/kWh) x utilization yield (kWh) | |
| 2 | Water | CEF (kg $CO_2$/$m^3$) x utilization yield ($m^3$) | |
| 3 | Wastewater (process) Wastewater (domestic) | CEF (kg $CO_2$/$m^3$) x production yield ($m^3$) | |
| 4 | Non-scheduled solid wastes | CEF (kg $CO_2$/kg) x production yield (kg) | |
| 5 | Scheduled wastes (solid) | CEF (kg $CO_2$/kg) x production yield (kg) | |
| 6 | Fuel | CEF (kg $CO_2$/kg) x utilization yield (kg) | |
| | **Total** | | |

## 9.3 SUMMARY OF AUDIT FINDINGS

The findings from the GIA should be summarised in a report for ease of analysis. The summary of the audit finding can be developed with the following structure:

a. Company general information (of the premise)

b. GIA Information
   i. Objectives
   ii. Scope
   iii. Methodology

c. Summary of GIA Findings
   i. $CO_2e$ analysis
   ii. Wastewater generation
   iii. Generation of Scheduled waste
   iv. Generation of Non-scheduled waste
   v. Material Loss / Wastage
   vi. Electricity Loss / Wastage
   vii. Energy Loss / Wastage
   viii. Health and safety issues
   ix. Housekeeping issues
   x. Other issues observed

d. Preliminary recommendations

e. Conclusion

A sample of Audit Finding Report is shown in Appendix 5.

# 10. PHASE 3: GENERATION OF GREEN INDUSTRY OPTIONS

GI options are generated with focus on the use of raw materials and utilities (electricity, water, fuel), generation of wastes, environmental conditions of the premise, storage of raw materials and products and other general aspects.

## 10.1 METHODOLOGY FOR GENERATING OPTIONS

GI options are generated after the audit and audit findings analysis. Examples of GI options include housekeeping, modification of design and operation, substitution of raw materials and change of technologies and operating procedures. Table 10.1 gives a detailed explanation on generation of GI options. It should be noted that probing questions could help the auditors in generating GI options.

**Table 10.1: Generation of GI Options**

| ACTIVITY | : | GENERATION OF GI OPTIONS |
|---|---|---|
| Objectives | : | • Generate ideas in identifying potential improvements in various aspects<br>• List as many potential improvements as possible with different difficulty levels in terms of implementation |
| Targeted areas | : | Target entity |
| Implementation methodology | : | Brainstorming |
| References | : | Audit findings |
| Tools | | Probing question |
| Outputs | : | GI options |
| Tips | : | • Generate as many GI options as possible<br>• Note down all the GI options<br>• Get feedback from the GI team to identify and prioritize the most suitable GI options |

During the brainstorming session with the GI team members, the following probing questions can be used to generate GI options.

1. Use of keywords found in the waste reduction hierarchy which are remove, prevent, reduce, reuse, recycle, treat and dispose of.
2. Use of GI strategies which include rearrangement, modification of design and operation, change of raw materials, technologies and operating procedures.
3. Relate the existing issues to their causes. For example, spillage of raw materials is caused by inefficient handling of raw materials. Identify the causes of such inefficiency and propose solutions.

## 10.2 TYPES OF GENERAL OPTIONS

Green industry strategy is totally different from the end-of-pipe treatment as it focuses on prevention or reduction of waste at sources. The main GI strategies involve rearrangement, modification of design and operation and change of raw materials, technologies and operating procedures. Table 10.2 summarises a few possible GI options for different operations that may be used.

**Table 10.2: GI options for different operations**

| RAW MATERIALS RECEIVING | | |
|---|---|---|
| **No.** | **Suggested Options** | **Benefits of Options Implementation** |
| 1. | Establish standard working procedures for staff | • Prevent energy wastage due to reprocessing<br>• Prevent waste generation from off-spec products |
| 2. | Separate solid wastes accordingly | • Increase the reuse and recycling rate of materials |
| 3. | Arrange materials/ products properly into bags | • Reduce waste generation from expired raw materials<br>• Increase productivity<br>• Reduce contamination |
| 4. | Establish the First-In-First-Out (FIFO) Programme | • Reduce waste generation from expired raw materials<br>• Increase productivity |

| MAIN AND AUXILIARY PROCESS | | |
|---|---|---|
| **No.** | **Suggested options** | **Benefits of Options Implementation** |
| 1. | Optimize blending/reaction time | • Reduce electricity usage<br>• Increase productivity |
| 2. | Use of mixer of appropriate capacity | • Reduce electricity usage |
| 3. | Reduce the needs to change the product types (types of products) | • Reduce liquid waste from clean-in-place (CIP) and rinsing<br>• Reduce energy usage needed for generation of hot water for CIP<br>• Reduce start-up and shutdown losses |
| 4. | Install motors with variable speed drive | • Reduce electricity usage through optimization of the mixing process |
| 5. | Optimise the design of the mixing tank so that it can be emptied fully | • Reduce loss of materials during the changing (change of products) process<br>• Reduce the burden of IETP |

| PACKAGING | | |
|---|---|---|
| **No.** | **Suggested options** | **Benefits of Options Implementation** |
| 1. | Train the workers in order to reduce loss of materials and products | • Reduce waste generation due to spoiled packaging materials |
| 2. | Optimise the speed of the packaging machines | • Increase productivity. |
| 3. | Make sure that the products and raw materials are wrapped properly | • Reduce waste generation from spoiled raw materials and products due to improper storage |
| 4. | Return the spoiled packaging materials to the supplier | • Prevent solid waste from spoiled packaging materials |

# 11. PHASE 4: ASSESSMENT AND PRIORITIZATION OF GREEN INDUSTRY OPTIONS

GI options should be assessed to make sure that they yield returns to the premise. The feasibility of GI options in various aspects has to be considered prior to implementation. Implementation cost, time and resources requirement have to be identified. In this topic, the relevant assessment criteria are discussed to assess the feasibility of GI options.

## 11.1 ASSESSMENT OF RESOURCES REQUIREMENT

The resources needed for GI options implementation have to be considered. Table 11.1 lists the resources required and their associated implications.

**Table 11.1: Resources requirements**

| NO. | REQUIRED RESOURCES | IMPLICATION | ASSESSMENT METHOD |
|---|---|---|---|
| 1. | Financial investment (capital investment) | • High financial investment usually requires a longer payback period<br>• Returns in the other forms have to be taken into account to make sure that the financial investment is worthy<br>• The investment cost has to be considered | • Payback Period<br>• Return on Investment (ROI) |
| 2. | Manpower | • Some GI options require manpower and expertise<br>• Some GI options require change of working procedures and training of the existing staff | • Impact on manpower<br>• Impact on cost of manpower |
| 3. | Time | • GI options which involve modification of equipment and structure require installation time<br>• Non-operating time should be considered | • Allowed downtime of the plant |

## 11.2 ASSESSMENT OF RETURN

The returns of GI options should be assessed. Table 11.2.1 lists the types of returns and their associated implications.

**Table 11.2.1: Types of return**

| NO. | RETURNS | IMPLICATIONS | ASSESSMENT METHOD |
|---|---|---|---|
| 1. | Resolution of issues | • Evaluate if the issues are thoroughly solved | • Target of the resolution of the issues |
| 2. | Increase in productivity or quality | • The targeted return has to be specifically identified | • Target should be consistent with the long-term aim of the premise |
| 3. | Cost reduction | • All risks have to be considered<br>• Safety and legal requirement have to be considered<br>• Financial cost, operational cost and modal have to be considered | • Reduction rate |
| 4. | Reduction of risk and increase in safety level | • All risks have to be considered<br>• Safety and legal requirement have to be considered | • Safety issues and risks are reduced |
| 5. | Reduction of environmental impacts | • The targeted return has to be specifically identified.<br>• The cost involved should be compatible | • Target should be consistent with the long-term aim of the premise |
| 6. | Improvement in the company's reputation | • The targeted return has to be specifically identified.<br>• The cost involved should be compatible | • Target should be consistent with the long-term aim of the premise |
| 7. | Increase in workers' confidence | • The cost involved should be compatible | • Target should be consistent with the long-term aim of the premise |

Cost assessment helps determine the positive economic return from the implementation of GI options. It includes identification and calculation of all expected returns. The typical assessment method is Payback Period that reflects the duration needed to recover the relevant investment. The formula of Payback Period is as follows:

$$\text{Payback Period} = \frac{\text{(Total investment on GI option )}}{\text{(Total returns /month)}}$$

Table 11.2.2 and Table 11.2.3 show the examples of calculation for payback period.

**Table 11.2.2: Installation of 4 transparent roofing panels to replace light bulbs.**

| | ITEM | TOTAL (RM) |
|---|---|---|
| **Investment cost** | Electrical work (i.e.: wiring) | |
| | Purchase of equipment | 600 |
| | Installation | |
| | Loss of income during the shut-down period | |
| | Labour cost | 600 |
| | Financial cost | |
| | Other cost | |
| | Total | 1,200 |
| **Increase in operating cost due to modifications (monthly basis)** | Item | |
| | Manpower | |
| | Electricity | |
| | Steam | |
| | Fuel | |
| | Maintenance | |
| | Treatment | |
| | Other cost | |
| | Total | 0 |
| **Return rate (monthly basis)** | Item | |
| | Manpower | |
| | Electricity | 212 |
| | Steam | |
| | Fuel | |
| | Maintenance | |
| | Treatment | |
| | Other cost | |
| | Total | 212 |
| **Payback period** | RM 1,200 / (RM 212/month) = 6 months | |

Typically, the payback period for GI options that require high investment is between 3 to 5 years. However, the payment period is only between 1 to 2 years for those options with moderate investment.

**Table 11.2.3: Installation of high pressure nozzles for cleaning purpose to save water usage.**

| | ITEM | TOTAL (RM) |
|---|---|---|
| **Investment cost** | Electrical work (i.e.: wiring) | |
| | Purchase of equipment | 80 |
| | Installation | |
| | Loss of income during the shut-down period | |
| | Labour cost | |
| | Financial cost | |
| | Other cost | |
| | Total | 80 |
| **Increase in operating cost due to modifications (monthly basis)** | Item | |
| | Manpower | |
| | Electricity | |
| | Steam | |
| | Fuel | |
| | Maintenance | |
| | Treatment | |
| | Other cost | |
| | Total | 0 |
| **Return rate (monthly basis)** | Item | |
| | Manpower | |
| | Electricity | |
| | Steam | |
| | Fuel | |
| | Maintenance | |
| | Treatment | 50 |
| | Water consumption | 15 |
| | Total | 65 |
| **Payback period** | RM 80 / (RM 65/month) = 2 months | |

There are many cases in the industry that small investments can yield returns with significant quick return on investments. The collective reduction of $CO_2e$ for a premise can be as much as 20-30% from these small investments.

### 11.3 REDUCTION OF CARBON DIOXIDE EQUIVALENT EMISSION

Returns of GI options in the form of reduction of carbon dioxide emission should be reported. Carbon dioxide emission values can be the main or additional criteria to assess the feasibility and prioritization of the GI options. The potential reduction of carbon dioxide emission of each GI option can be measured by comparing it with the existing carbon dioxide emission of the premise.

Example of GI options:
Installation of 4 transparent roofing panels

| | | |
|---|---|---|
| **Details of returns** | : | **Item** |
| | | Reduction in electricity usage<br><br>Electricity usage for the premise<br>= 142,357kW.hr / month @ RM50,000.00<br><br>The savings come from when lights are switched off in the daytime when the natural lighting is used as replacement for 60 units of 40W bulbs. The savings can be as much as 70% operational time (typically 12-18 hrs/day) for lighting.<br><br>Electricity usage from 60 light bulbs<br>= 60 units x 40 W/unit x 12 hrs/day x 30 day/month<br>= 864 kWh/ month<br><br>Electricity savings for lighting<br>= 70% x 864 kW.hr/ month<br>= 604.8 kW.hr/ month |
| | | Reduction of carbon dioxide emission for lighting<br><br>= Electricity savings x carbon emission factor<br>= 604.8 kW.hr/ month x 0.67 kg $CO_2$/ kW.hr<br>= 405.2 kg $CO_2$ / month |

## 12. PHASE 5: IMPLEMENTATION AND MONITORING OF GREEN INDUSTRY OPTIONS

Implementation and performance monitoring of GI options have to be planned and conducted continuously. Feedbacks on the efficiency of GI options have to be collected regularly. The frequency of data collection and feedback depends on the targeted aspects. Please refer to the sample options performance monitoring form in Appendix 4.

Monitoring is needed to make sure the objectives of GI strategy implementation are met fully. The latest achievement level and efficiency of the GI options should be recorded. The collected information should be evaluated and corrective/ alternative measures should be taken if needed. A sample monitoring form is attached in Appendix 4. Table 12.1 lists the general aims of GI options and their associated monitoring aspects.

**Table 12.1: Aims of GI options and their associated aspects for monitoring**

| NO. | GENERAL AIM | MONITORED ASPECT | IMPLICATIONS |
|---|---|---|---|
| 1. | Reduction of carbon dioxide emission | • Carbon dioxide emission of each contributing entity<br>• Production/ utilization rate of each entity should be considered | • Regular monitoring can be done<br>• Benchmarking against the global standard can be done |
| 2. | Reduction of electricity usage | • Cost of electricity<br>• Dependency (percentage) on the energy from grid<br>• Utilization percentage of alternative energy (i.e. solar energy) | • Regular monitoring can be done by recording the bill<br>• An overall target can be fixed and current achievement can be evaluated<br>• Reduction of carbon dioxide emission can be measured |
| 3. | Reduction of water usage | • Cost/ bill of water usage<br>• Recycling percentage of water at the premise | • Regular monitoring can be done by recording the bill<br>• An overall target can be fixed and current achievement can be evaluated<br>• Reduction of carbon dioxide emission can be measured |
| 4. | Reduction of fuel usage | • Fuel usage<br>• Cost/ bill of fuel usage | • Regular monitoring can be done by recording the bill<br>• Reduction of carbon dioxide emission can be measured |
| 5. | Reduction of solid waste generation | • Solid waste generation<br>• Recycling percentage of solid waste<br>• Percentage of solid waste | • Regular monitoring can be done by recording the bill<br>• Reduction of carbon dioxide emission can be measured |
| 6. | Reduction of wastewater generation | • Wastewater generation<br>• Burden to IETS<br>• Record of the produced sludge | • Regular monitoring can be done by recording the burden to IETS<br>• An overall target can be fixed and current achievement can be evaluated<br>• Reduction of carbon dioxide emission can be measured |
| 7. | Reduction of safety risk | • Record of accidents<br>• Record of employees' sick leave | • Continuous monitoring of the record<br>• Can have an impact on the insurance premiums of employees |
| 8. | Increase in productivity or quality | • Production record<br>• Percentage of rejected products | • Continuous monitoring of the record |

## 13. PHASE 6: CONTINUOUS IMPROVEMENT

Green Industry initiative is a strategy that emphasizes prevention rather than treatment. There are a few methods and steps that can be adopted for GI implementation at a premise. The following are some general steps that can be considered.

- Establish the commitment among the management and workers through environmental policies and campaigns by integrating GI in their daily practice at the premise.
- Increase the environmental awareness level among the workers.
- Form a GI team to continually conduct assessment activities, identify issues, generate GI options, monitor and record the performance of the plant.
- Announce the achievement status of GI objectives to the management and workers of the premise.
- Involve the local enforcement authorities that are responsible for environmental quality.
- Inform the neighbouring premises or the suppliers about the commitment of the premise towards GI implementation.

GI planning, implementation and performance of the premise should be continuously recorded to assess the current achievement of the premise and serve as a reference for continuous improvement. Record keeping is helpful for implementation of GI initiatives at a premise.

- There should be written records of the current status of waste generation, energy usage, water usage and other main issues of the company. Such information can be readily available and referred to when needed.
- Written records of the activities at the premise serve as a pollution prevention measure.
- Records can be used as a proof that the company is committed towards environmental conservation. Many international and local companies/ consumers make this a requirement.
- Planning and assessment lead to systematic analysis and development of standards in improving the premise's performance and cost savings.

Documents and records can be kept in the following forms:

- Environmental Policy
- Environmental Action Plan
- Records of staff training, instruction, treatment of wastes, regular inspection and maintenance schedule

# **Appendix 1:**
# Sample Checklist

**Appendix 1: Sample Checklist**

| | | |
|---|---|---|
| Date of Walkthrough | : | |
| Company's Name | : | |
| Address | : | |
| Name of Auditors | : | |

Company profile Yes ❑ No ❑ Incomplete ❑
Person in-charge: _____

Process flow chart Yes ❑ No ❑ Incomplete
Person in-charge: _____

List of equipment and specification Yes ❑ No ❑ Incomplete
Person in-charge: _____

Utilities bill Yes ❑ No ❑ Incomplete
Person in-charge: _____

Arrangement plan of equipment Yes ❑ No ❑ Incomplete
Person in-charge: _____

Production records of main products Yes ❑ No ❑ Incomplete
Person in-charge: _____

Production records of by-products Yes ❑ No ❑ Incomplete
Person in-charge: _____

Records of raw materials Yes ❑ No ❑ Incomplete
Person in-charge: _____

Records of wastes Yes ❑ No ❑ Incomplete
Person in-charge: _____

Records of IETS Yes ❑ No ❑ Incomplete
Person in-charge: _____

Records of workers' safety Yes ❑ No ❑ Incomplete
Person in-charge: _____

Records of compliance to EQA 1974 Yes ❑ No ❑ Incomplete
Person in-charge: _____

# **Appendix 2:**
# Sample Implementation Schedule

## Appendix 2: Sample Implementation Schedule

| | | |
|---|---|---|
| Name of Audit | : | Green Industry Audit |
| Company's name | : | |
| Address | : | |
| Team members | | |
| Name of Auditor 1 | : | |
| Name of Auditor 2 | : | |
| Name of Auditor 3 | : | |

| NO. | ACTIVITY | MILESTONES | | | | | |
|---|---|---|---|---|---|---|---|
| | | MONTH 1 | MONTH 2 | MONTH 3 | MONTH 4 | MONTH 5 | MONTH 6 |
| 1 | Formation of a team responsible for Green Industry programme at the premise | | | | | | |
| 2 | Pre-audit visit to identify audit objectives and scopes | | | | | | |
| 3 | Auditing and information collection activities | | | | | | |
| 4 | Data analysis | | | | | | |
| 5 | Progress meeting/ presentation | | | | | | |
| 6 | Generation of Green Industry options for the premise | | | | | | |
| 7 | Assessment and prioritization of Green Industry options | | | | | | |
| 8 | Progress meeting/ presentation | | | | | | |
| 9 | Implementation of GI options and monitoring | | | | | | |
| 10 | Analysis of returns | | | | | | |
| 11 | Report preparation | | | | | | |

# **Appendix 3:**
# Sample Audit Form

## Appendix 3: Sample Audit Form

| PART 1a: AUDIT INFORMATION | | | |
|---|---|---|---|
| **NO** | **ITEM** | | **INFORMATION** |
| 1 | Audit objectives | : | |
| 2 | Audit scopes | : | |
| 3 | Name of auditors | : | |

| PART 1b: BASIC INFORMATION | | | |
|---|---|---|---|
| **NO.** | **INFORMATION** | | **DETAILS** |
| 1 | Company Name | : | |
| 2 | Company Address | : | |
| 3 | Company Homepage | : | |
| 4 | Category of Industry | : | |
| 5 | Number of Employee | : | |
| 6 | Operating Hour | : | |
| 7 | Year of Operation | : | |
| 8 | Information of other branch | : | |
| 9 | Enforcement and Compliance History (DOE-involved) | : | |
| 10 | Recent Development | : | |
| 11 | Factory/Company Ownership | : | |
| 12 | Targeted Market | : | |
| 13 | Certification | : | |

| PART 2: MAIN PRODUCTS | | | |
|---|---|---|---|
| **NO** | **PRODUCT** | **PRODUCTION RATE /MONTH** | **PACKAGING TYPE** |
| 1 | | | |
| 2 | | | |

| PART 3: BY PRODUCTS | | | |
|---|---|---|---|
| **NO** | **PRODUCT** | **PRODUCTION RATE /MONTH** | **PACKAGING TYPE** |
| 1 | | | |
| 2 | | | |

| PART 4: RAW MATERIAL CONSUMPTION | | |
|---|---|---|
| **NO** | **RAW MATERIAL** | **PRODUCTION RATE /MONTH** |
| 1 | | kg/ month |
| 2 | | kg/ month |

| PART 5a: UTILITY | | |
|---|---|---|
| **NO** | **UTILITY** | **PRODUCTION RATE / MONTH** |
| 1 | Water (Tips: refer to water bill) | $m^3$/month |
| 2 | Electricity (Tips: refer to electricity bill) | kW.hr/month |
| 3 | Others | |

| PART 5b: WATER CONSUMPTION | | |
|---|---|---|
| **NO** | **TYPE OF USAGE** | **PRODUCTION RATE /MONTH** |
| 1 | Process | $m^3$/month |
| 2 | Domestic | $m^3$/month |
| 3 | Other types of usage. | |
| | | |

| PART 5c: FUEL CONSUMPTION | | | |
|---|---|---|---|
| **NO** | **FUEL TYPE** | **TYPE OF USAGE** | **PRODUCTION RATE /MONTH** |
| 1 | | example: forklift | kg/month |
| 2 | | example: boiler | kg/month |
| 3 | | | |

| PART 6: PROCESS FLOW DIAGRAM |
|---|
| |

| PART 7: UNIT OPERATION /ACTIVITY | | |
|---|---|---|
| **NO.** | **NAME** | **FUNCTION** |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

| PART 8: OTHER ACTIVITY | | |
|---|---|---|
| **NO.** | **ACTIVITY** | **FUNCTION** |
| 1 | | |
| 2 | | |

| PART 9: FACILITY | | |
|---|---|---|
| **NO.** | **FACILITY** | **FUNCTION** |
| 1 | | |
| 2 | | |
| 3 | | |

| PART 10: WASTE QUANTIFICATION | | | | |
|---|---|---|---|---|
| 10a: WASTEWATER | | | | |
| **NO.** | **SOURCE** | **AMOUNT GENERATED ($m^3$/month)** | **WASTEWATER CHARACTERISTIC** | |
| | | | **COD (mg/l)** | **BOD (mg/l)** |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

| PART 10b: NON-SCHEDULED WASTE | | | |
|---|---|---|---|
| **NO.** | **WASTE** | **LOCATION** | **AMOUNT GENERATED** |
| 1 | | | |
| 2 | | | |

| PART 10c: SCHEDULED WASTE | | | |
|---|---|---|---|
| **NO.** | **WASTE** | **LOCATION** | **AMOUNT GENERATED** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

| PART 11: GASEOUS EMISSIONS QUANTIFICATION | | | |
|---|---|---|---|
| **NO.** | **TYPE** | **LOCATION** | **AMOUNT RELEASED** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

| PART 12: RAW MATERIAL SPILLAGE/ DISCARDED PRODUCT /ETC | | | |
|---|---|---|---|
| **NO.** | **MATERIAL** | **POSSIBLE CAUSES** | **AMOUNT** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

| PART 13a: ENERGY LOSS FROM HOT SURFACE | | | | |
|---|---|---|---|---|
| **NO.** | **SOURCE** | **SURFACE AREA, A $m^2$ (ESTIMATION)** | **SURFACE TEMPERATURE, $T_s$ °C (ESTIMATION)** | **TOTAL HEAT LOSS (kW) Q = hA ($T_s$ - 28°C)/1000** |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

| PART 13b: ENERGY LOSS THROUGH HOT MATERIAL | | | | |
|---|---|---|---|---|
| NO. | SOURCE | MASS FLOWRATE, m (kg/s) (ESTIMATION) | MATERIAL TEMPERATURE, $T_b$ °C (ESTIMATION) | TOTAL HEAT LOSS (kW) Q = mCp ($T_b$ - 28°C) |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

| PART 13c: ENERGY LOSS THROUGH COLD MATERIAL | | | | |
|---|---|---|---|---|
| NO. | SOURCE | MASS FLOWRATE, m (kg/s) (ESTIMATION) | MATERIAL TEMPERATURE, $T_b$ °C (ESTIMATION) | TOTAL HEAT LOSS (kW) Q = mCp (28°C - $T_b$) |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

| PART 13d: ENERGY LOSS FROM LATENT HEAT (STEAM) | | | |
|---|---|---|---|
| NO. | SOURCE | RATE OF DISCHARGED m (kg/s) (ESTIMATION) | ENERGY LOSS Q = 2150m (kW) |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

| PART 14: SAFETY AND HEALTH RISK | | | |
|---|---|---|---|
| **NO.** | **OBSERVATION** | **COMMENT** | **SEVERITY LEVEL (1/2/3/4) 1-low risk 2-risk 3-high risk 4-to be addressed immediately** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| PART 15: COMPLAINT RECEIVED | | | |
|---|---|---|---|
| **NO.** | **COMPLAINT** | **FREQUENCY** | **ACTION TAKEN** |
| 1 | | | |
| 2 | | | |

| PART 16: HOUSEKEEPING ISSUES | | | |
|---|---|---|---|
| **NO.** | **ISSUES** | **LOCATION** | **EFFECT ON QUALITY/ PRODUCTIVITY/SAFETY** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

| PART 17: OTHER OBSERVATION | | | |
|---|---|---|---|
| **NO.** | **OBSERVATION** | **LOCATION** | **EFFECT ON QUALITY/ PRODUCTIVITY/SAFETY** |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

# **Appendix 4:**
# Sample Options Performance Monitoring Form

## Appendix 4: Sample Options Performance Monitoring Form

| | | | |
|---|---|---|---|
| **Issue** | : | | |
| **Area** | : | | |
| **Source / cause** | : | | |
| **Option** | : | | |
| **Possible challenges** | : | **Types of challenges** | **Tick (√)** |
| | | 1. No expertise | |
| | | 2. Low commitment from the management | |
| | | 3. Manufacturing process cannot be stopped | |
| | | 4. Too risky | |
| | | 5. Impairs product quality | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| **Required Resources** | : | **Required Resources** | **Tick (√)** |
| | | 1. Technology | |
| | | 2. Manpower | |
| | | 3. Training | |
| | | 4. Awareness | |
| | | 5. Process modification | |
| | | 6. Modification of operational parameters | |
| | | 7. Change of materials | |
| | | 8. Design modifications | |
| | | 9. Standard Operating Procedures (SOP) | |
| | | 10. Monitoring | |
| | | 11. Additional control | |
| | | 12. Research and development (R&D) | |
| | | 13. Approval from the authority | |
| | | | |
| **Investment cost** | : | **Item** | **Required amount (RM)** |
| | | 1. Electrical work (i.e.: wiring) | |
| | | 2. Purchase of equipment | |
| | | 3. Installation work | |
| | | 4. Loss of income during shut-down period | |
| | | 5. Labour cost | |
| | | 6. Financial cost | |
| | | 7. Other cost | |
| | | **TOTAL (A)** | |

| | | | |
|---|---|---|---|
| **Increase in operating cost due to modifications (monthly basis)** | : | **Item** | **Required amount (RM)** |
| | | 1. Manpower | |
| | | 2. Electricity | |
| | | 3. Steam | |
| | | 4. Fuel | |
| | | 5. Maintenance | |
| | | 6. Treatment | |
| | | 7. Other cost | |
| | | **TOTAL (B)** | |
| **Returns (monthly basis)** | : | **Item** | **Returns (RM)** |
| | | 1. Manpower | |
| | | 2. Electricity | |
| | | 3. Steam | |
| | | 4. Fuel | |
| | | 5. Maintenance | |
| | | 6. Treatment | |
| | | 7. Other cost | |
| | | **TOTAL RETURNS (C)** | |
| **Payback period** | : | **A/(C-B) month** | |
| **Other returns** | : | **Types of returns** | **Tick (√)** |
| | | 1. Improvement in quality | |
| | | 2. Improvement in image | |
| | | 3. Safer operation | |
| | | 4. Operation that is less risky | |
| | | 5. Increase motivation | |
| | | 6. Working environment that is more comfortable | |
| | | 7. Less environmental issues | |
| | | 8. Reduction of carbon footprint | |
| | | 9. Other returns | |
| **Implementation merit** | : | **Merit** | **Tick (√)** |
| | | Immediate implementation | |
| | | Implementation within 6 months | |
| | | Implementation when there is financial support | |
| | | Keep in view (KIV) | |
| | | Re-assessment after 10 years | |
| | | Abortion of plans | |
| **Required documentation for implementation** | : | **Types of documents** | **Tick (√)** |
| | | Documentation | |
| | | Video | |
| **Monitoring plan (Explain)** | : | | |
| **Prepared by** | : | | |
| **Verified by** | : | | |

# **Appendix 5:**
# Sample of Audit Finding Report Format

## 1. COMPANY'S GENERAL INFORMATION

| | | |
|---|---|---|
| Name of Premise | : | |
| Address | : | |
| Telephone / Fax Number | : | |
| Company's Representative | : | |

## 2. GREEN INDUSTRY AUDIT Information

### a. Objectives

| |
|---|
| |

### b. Scope

| |
|---|
| |

### c. Methodology

| |
|---|
| |

## 3. SUMMARY OF AUDIT FINDINGS

**Carbon Dioxide Emission ($CO_2e$) Analysis**

| NO. | ENTITY | CARBON DIOXIDE EMISSION RATE | PERCENTAGE |
|---|---|---|---|
| 1 | Electricity | CEF (kg $CO_2$/kW.hr) x utilization yield (kW.hr) =_____ | |
| 2 | Water | CEF (kg $CO_2$/$m^3$) x utilization yield ($m^3$) =_____ | |
| 3 | Wastewater (process) Wastewater (domestic) | CEF (kg $CO_2$/$m^3$) x production yield ($m^3$) =_____ | |
| 4 | Non-scheduled solid wastes | CEF (kg $CO_2$/kg) x production yield (kg) =_____ | |
| 5 | Scheduled wastes (solid) | CEF (kg $CO_2$/kg) x production yield (kg) =_____ | |
| 6 | Fuel | CEF (kg $CO_2$/kg) x utilization yield (kg) =_____ | |
| | **Total** | | |

a. Wastewater Generation

b. Generation of Scheduled Waste

c. Generation of Non-scheduled Waste

d. Material Loss / Wastage

e. Electricity Loss / Wastage

f. Energy Loss / Wastage

g. Health & Safety Issues

h. Housekeeping Issues

i. Other issues

## 4. PRELIMINARY RECOMMENDATIONS

## 5. CONCLUSION


Http://www.doe.gov.my

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