# Green Production Assessment Scheme for Plastic Bag Manufacturing Industry – Local Industrial Analysis and Best Operation Practices

# 塑料袋業之綠色生產評估計劃 — 行業分析及最佳運作典範


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*Green Production Assessment Scheme for Plastic Bag Manufacturing Industry –*

# *Local Industrial Analysis and Best Operation Practices*

## *塑料袋業之綠色生產評估計劃 —*

# *行業分析及最佳運作典範*

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# *Foreword*

"Solid Waste Reduction" is one of the hottest topics in the territory recently. The production rate of solid waste is now at an unacceptable level that the landfills in Hong Kong will be filled up in 6 to 10 years. Out of the many different kinds of solid waste, plastic shopping bags and packaging are regarded as extraordinarily harmful substances to our environment. Voices for banning the free distribution of plastic bags and levying taxes to deter their uses are all around. Usage and production of plastic bags become highly concerned issues in the world as well. International communities have actively set up measures to reduce plastic bag waste. Several countries have already enforced taxes on plastic bags in the hope to reduce plastic bag consumption while encourage recycling.

Everything seems to go right. However, there are some occasions where plastic bag and film packaging are unavoidable. "Problems" still exist. The Government has taken some measures in dealing with the disposal and recycling of plastic bag and film packaging products. However, not much effort has been paid to work with the "root" cause of the problem, i.e. the design and production of these products. The industry now faces a crisis that has never existed. In order to deal with this challenge, plastic bag and film packaging manufacturers have to step forward to adopt the green design and production concepts for their industry.

To assist the industry to understand plastic bag ecodesign and green production concepts as well as the technical requirements, and to foster a positive image towards plastic bag production, the Hong Kong Plastic Bag Manufacturers' Association, cooperated with the Hong Kong Productivity Council, applied and was successfully granted the SME Development Fund to run the project "To promote and adopt environmental friendly concepts and technologies for the life cycle of plastic film packaging". The project aims to research advanced environmental friendly technologies, concepts and practices regarding the production of plastic film packaging and define a set of green assessment criteria concerning the whole plastic bag production cycle. The criteria were defined

regarding to 4 categories: Energy Management, Noise Pollution, Management System and Product Design. The assessment scheme aims to credit the efforts the industry has put to improve green product development and production. It also aims to identify the weaknesses of the industry in these areas. The Hong Kong Plastic Bag Manufacturers' Association will decide whether to present Green Certificate to the audited company based on the assessment results.

On-site auditing of 5 representing companies from the industry were carried out to identify the advanced technologies and operation practices that are feasible for the industry and to develop guidelines focusing on 4 categories: energy management, noise pollution, management system and product design such that they were able to revise their management practices to a more environmentally friendly level in response to the stringent environmental protection obligations as well as the social responsibility requirements demanded by various regulatory or voluntary bodies in Hong Kong, Mainland China and overseas.

A set of 2 guidebooks featuring all the technical issues about the green production assessment scheme of the plastic bag and film packaging, and recommendation and advice on possible measures to achieve green design and production was published. Guidebook 1 details all the technical issues about the green production assessment scheme and Guidebook 2 focuses on industry green production analysis, technology and "best operation practices".

We would like to thank the Hong Kong Plastic Bag Manufacturers' Association and the participated pilot companies for their kind consent to support the pilot run. We also wish that, through this assessment scheme, the Hong Kong plastic bag manufacturing industry could enhance its competitiveness by continuously identifying its weaknesses and adopting the "best operation practices".

# 前言

「減少固體廢物」是近年本地其中一個最熱門的話題。現時本港固體廢物的產生速度，已達致不能接受的水平，香港的堆填區將會在6至10年內填滿。因此，政府的首要工作是訂立一套可行的解決方案。在芸芸眾多的固體廢物中，塑料購物袋和包裝材料被認定為對環境異常有害的物質。「反對免費派發膠袋」以及「徵收膠袋稅」之聲絡驛不絕，希望藉此起阻嚇作用。加上全球環保意識日漸提高，國際社會對塑料袋的製造與應用日益關注，很多國家已經積極地採取措施，以冀減少塑料袋廢物，多個國家已開始強制徵收膠袋稅，希望大眾減少濫用塑料袋，並鼓勵回收循環再造。

所有行動似乎理所當然。但是，在現實生活中，總有些情況是無可避免地要使用塑料袋及塑料薄膜包裝材料。這個問題依然存在。另外，現時政府已在塑料袋或塑料薄膜產品的棄置及回收方面推行改善措施。但是，在針對這些問題的根本成因，即產品設計及生產方面，則著墨不多。業界正面臨一個從未出現過的危機。為了應付這種挑戰，塑料袋及包裝製造商必須向前踏出一步，採納綠色環保設計及生產等概念。

為幫助業界更了解塑料袋環保設計及生產的理念及技術上的考慮，及改變大眾對塑料袋固有的印象，香港塑料袋業廠商會聯同香港生產力促進局早前已申請並成功獲得中小企業發展支援基金撥款資助開展了一個名為“推動與實踐有關塑料薄膜包裝之生命周期的綠色環保概念與技術”的項目。這個項目旨在對環球市場上出現的一些綠色生產先進技術、概念及典範運作模式進行研究及參考，並訂立一套涵蓋整個塑料袋和包裝生命週期的綠色生產評估系統，作為本地塑料薄膜包裝生產商進行專業評估的指標。量度指標包括：能源管理、噪音污染、管理系統及產品設計，目的是讚揚業界在綠色開發和生產的表現及協助業界找出不足之處。香港塑料袋業廠商將會跟據評審結果決定是否頒予綠色認証。

計劃中已為本地5間具代表性的公司進行先導審核，藉此鑑別出業界可行的技術及運作方案，以及編制一套針對能源管理、噪音污染、管理系統及產品設計四方面的通用守則，以協助他們將其管理運作提昇至更環保的水平，令本地塑料薄膜包裝製造商更有能力應對本地、中國大陸和海外各監管或志願機構的嚴格環境保護規條和社會責任。

此項目將所有關於塑料薄膜包裝綠色生產評估計劃的技術性資料、本地業界的現況分析、達致綠色設計及生產可行方案的建議等，整理結集成一套兩本的手冊供業界參考。手冊一內將詳列了綠色生產評估的評審資料，手冊二內則詳列了本地業界的現況分析、技術及『最佳運作典範』等。

我們在此鳴謝香港塑料袋業廠商會及參與計劃的先導公司的支持，謹希望香港的塑料袋業能夠善用此綠色生產評估計劃，找出弱點，並應用『最佳運作典範』來提升競爭力。

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# Chapter 1

# Executive Summary

# Chapter 1

# Executive Summary

A set of green assessment criteria concerning the whole plastic bag production cycle was defined for the Green Production Assessment Scheme for Plastic Bag Manufacturing Industry. The criteria were grouped into 4 categories: Energy Management, Noise Pollution, Management System and Product Design.

With the support and cooperation of five participating pilot companies from the plastic bag manufacturing industry, we successfully gathered information on the daily production and operation of several representative plastic bag manufacturing plants in order to acquire the general practices of the local industry.

For Energy Management, the industry average grade was 2.7, i.e. just a fair performance grade. There are still many improvement areas for the industry. For Noise Pollution, the industry average grade was 3, i.e. also fair as compared to the set criteria. However, as we discovered that the major noise came from the background noise, the industry was actually doing quite well in this category. For Management System, the average grading was 1. It seems that it is not a common practice for the industry to implement green manufacturing management practices, such as ISO14000 which is a quite widely accepted practice in other industries. For Product Design, the industry average grading was 2.6. The industry actually did not have the initiative to adopt eco-/green- design on their products. However, they did, to a certain extent, apply various materials or additives in order to reduce the use of virgin materials.

From the assessment results, it seems that there are still a lot to be done by the plastic bag manufacturing industry to become a green production industry. And some suggestions are provided in this book as simple and quick tips for the manufacturers to follow. These suggestions may have been already known by everyone but were rarely put into practice. A minor step in daily operation may make a big change in the plant's overall green production performance.

# Chapter 2

# Plastic Bag Manufacturing And Materials

Chapter 2

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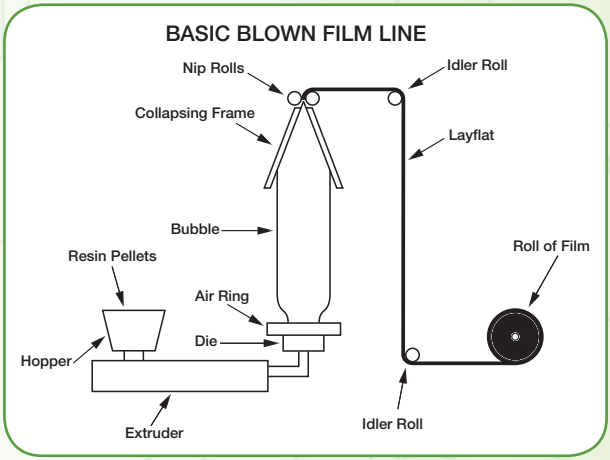
## 2.1 Plastic Bag Manufacturing

The plastic bag manufacturing starts with plastic film production that involves the processing of any plastic into a film and calls for the plastic resins to be melted, fed into a shaping exit die at a metered rate, cooled and fed to a wind-up station. Many variants and complexities can be added to this simple concept. The films produced are then value-added by printing, shaping, coating, laminating, stamping, slitting, forming and folding.

### Blown Film Extrusion (Film Blowing) Process

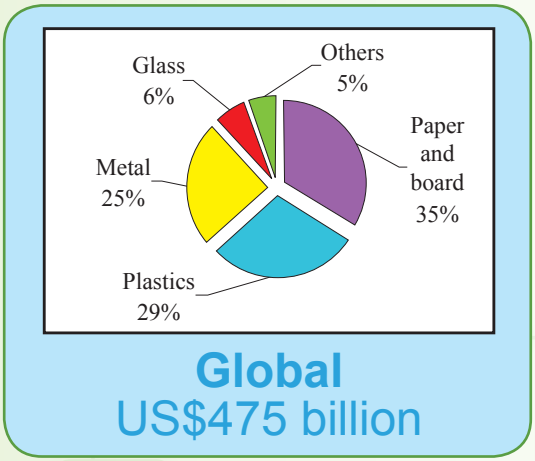



*(Source: http://plastics.turkavkaz.ru/processes/extrusion/blown-film-extrusion/)*

## 2.2 Types of Films and Materials

Packaging is an essential functional, aesthetic or protective element for millions of industrial and consumer goods ranging from basic chemicals to household and personal care products, food products, medical devices, drinks and many others.

Plastics play a significant role in the packaging industry for both functional and economic reasons. They are frequently low cost, lightweight alternatives to traditional materials but increasingly are being selected because of their superior functionality.




*(Source: Transdisciplinary Approaches to Waste Management: Theme: Consumers and Supply Chains Cardiff, Wales, 18th March 2004)*

A wide variety of plastics materials are used for films:

- Polyethylene (PE), high-density (PE-HD), low-density (PE-LD) and linear low-density (PE-LLD)
- Polypropylene (PP), mono-oriented (OPP), bi-oriented (BOPP) and Cast (CPP),
- Polyvinyl chloride (PVC)

- Polystyrene (PS) and oriented polystyrene (OPS)
- Polyester unsaturated, polyethylene terephthalate (PET)
- Ethylene vinyl alcohol (EVOH)
- Polyvinyl alcohol (PVA or PVOH)
- Polyvinylidene chloride (PVDC)
- Polyamides (PA6, PA11, PA12)
- Polycarbonate (PC)
- Cellulosics, cellophane (cello)
- The combinations of these films as multilayers, by all the processes used to obtain them, whether the final films are all plastics or a combination of plastics and other materials such as paper, cardboard and aluminum foil.

The nature and function of these various materials in the final flexible film vary greatly, and major distinctions run through the following:

- Commodity versus specialty performance materials
- Single or mono-materials versus multiplayer or composite materials
- Basic substrate materials versus enhanced added-value materials
- Packaging versus non-packaging applications
- Various primary or secondary processes used for obtaining films
- Various types of finished products

***In this project, we have focused on the PP and PE plastic bag single layer products only.***

## Polyethylene (PE)

Polyethylene films are the most widely used, representing some 75-80% of the total tonnage of plastic films.

LDPE has a linear molecular structure with long side-chain branches, which reduce the crystallinity. Copolymerisation with vinyl acetate and ethyl acrylate can reduce crystallinity even further. LDPE combines toughness, high impact strength, low brittleness temperature, low permeability to water, film transparency and good processability.

LLDPE has a linear molecular structure with no long-chain branching. Density is determined by the type and amount of copolymer used and ranges from 0.915 to 0.935. The crystallinity of LLDPE is higher than that of LDPE, raising the melting point of the resin by 10-15°C.

HDPE has a linear molecular structure with some short-chain branches. Typically 70% crystalline, with a density of 0.941-0.965, it has the best barrier and strength properties of all the polyethylenes. HDPE is valued for its high stiffness, tensile strength and heat resistance. HDPE is a very good insulator, with lower permeability to water and gases.

Metallocene polyethylene (mPE) is the most recent entrant in the widening range of the PE family. Metallocenes are termed “smart catalysts” that permit precise manufacturing control of specific resin properties. The first entry of metallocenes was in the early 1990s, and at the beginning they were scarce, expensive and hard to process. Since 1997, the next generation of metallocenes has been greatly improved, so that metallocenes are changing the very concept of polyolefins and other plastics.

## Polypropylene (PP)

Propylene molecules linked together to form long polymer chains are known as polypropylene. There are several basic types of PP, including homopolymers, copolymers, terpolymers and modified resins.

PP films are excellent moisture, odor and flavor barriers, and have excellent clarity and good heat seal properties. PP films are relatively low cost, lightweight (with a density of 0.91 g/$cm^3$, which is the lowest of all major plastics) and can be easily fabricated. PP films have been enjoying the fastest global growth in films, not only with the early replacement of the old cellophane (cello), but also in the opening up of new film markets.

# Chapter 3

# Degradable Testing

# Chapter 3

# Degradable Testing

Plastic bags pose a serious environmental concern these days. Degradable claims on plastic bags have made their way into the market. However, the real issue is to what extent degradability does take place to reduce the waste burden to the landfills.

There are several international recognized testing standards available for the verification of the degradability and compostability of plastic bags as follows:

Major Degradability / Compostability Testing Standards:

ISO 14855

EN 13432 (EU)

DIN V54900-1 (GERMANY)

ASTM D 6400 (US)

GreenPla (JAPAN)

AS4736 (AUSTRALIA)

The Hong Kong Environmental Protection Department (EPD) launched a ***"Testing Guideline on the Degradability and Food Safety of Containers and Bags" – the HS 2001*** in December 2000. It was the first comprehensive testing guideline for degradable products developed locally. It aims to test whether these degradable products are safe to human health and truly degradable.

In 1999, EPD formed a working group with the Hong Kong Plastics Technology Centre, Hong Kong Association of Certification Laboratories, Consumer Council, Hong Kong

University of Science and Technology, Food and Environmental Hygiene Department and the trade representatives to develop a testing guideline for degradable containers and bags as well as to establish the local criteria. The testing guideline was developed after making reference to relevant international testing methods and standards with due consideration of the characteristics of degradable materials and the local environment. The testing guideline addresses food safety, degradability and physical performance of degradable products. Producers and suppliers may appoint local laboratories to conduct the required tests.

The EPD has informed government departments and major catering companies of the launching of the testing guideline so they can make use of the testing guideline in selecting degradable products.

More information on the testing guideline and the associated registration scheme can be obtained from the EPD website at http://www.info.gov.hk/epd.

*(Source:http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/guide_hs2001.html)*

# Chapter 4

# Green Production Assessment Scheme for Plastic Bag Manufacturing Industry

Chapter 4

# Green Production Assessment Scheme for Plastic Bag Manufacturing Industry

## 4.1 Green Production Assessment Scheme

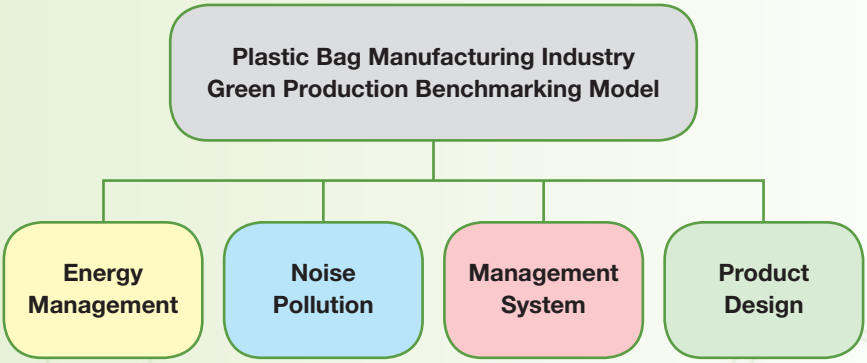
To assist the industry to understand plastic bag ecodesign and green production concepts as well as the technical requirements, and to foster a positive image towards plastic bag production, the Hong Kong Plastic Bag Manufacturers' Association, cooperated with the Hong Kong Productivity Council, applied and was successfully granted the SME Development Fund to run the project "To promote and adopt environmental friendly concepts and technologies for the life cycle of plastic film packaging".

A set of green assessment criteria concerning the whole plastic bag production cycle has been defined for the 『Green Production Assessment Scheme for Plastic Bag Manufacturing Industry』. The criteria were grouped into 4 categories: Energy Management, Noise Pollution, Management System and Product Design. The assessment scheme aims to credit the efforts the industry has put to improve green product development and production. It also aims to identify the weaknesses of the industry in these areas.

## 4.2 The Four-Category Model

Benchmarking is essentially a process of measuring and comparing operational efficiency and effectiveness across companies and industries. Through continuously comparing the business processes with the world leading companies, operation improvement information will be obtained. The objective is to learn from the most successful companies and find the "Best Practices" that lead to excellence and continuous improvement.

The "Green Production Assessment Scheme for plastic bag manufacturing industry" adopts a specially designed benchmarking model to assess the plastic bag manufacturing companies. A set of green assessment criteria concerning the whole plastic bag production cycle has been defined regarding to 4 categories: Energy Management, Noise Pollution, Management System and Product Design. The assessment scheme aims to assist the companies to understand their environmental performance, identify their strengths and weaknesses and define appropriate strategies for continuous improvement.




## 4.3 Categories Definition and Relation

The model is divided into 4 categories composing of 9 key performance indicators (KPIs) which represent the key concerns of green production for the plastic bag and film packaging industry.

- **Category 1 - Energy Management** is the outcome which reflects the overall efficiency in energy consumption. In order to conserve and sustain a green environment, the efficient use of energy makes a significant contribution in this direction, ensuring both the wiser use of the world's resources and the generation of less pollution in the production of energy.
  - KPI-1 Critical Process Energy Consumption (kWh/kg)
  - KPI-2 Workshops Specific Energy Consumption (kWh/kg)
  - KPI-3 Office Energy Consumption (kWh/$m^2$/annum)

- **Category 2 - Noise Pollution** is a direct measure on the noise level of a manufacturing plant. The bottom line is that the noise produced does not affect the environment around.
  - KPI-4 Noise Level (dB)

- **Category 3 - Management System** reflects the degree of commitment or comprehensiveness of a company's management standards towards environment.
  - KPI-5 Environmental Management System Standards

- **Category 4 - Product Design** measures the efforts a company has put to develop more environmentally friendly products. To determine if a product is environmentally friendly, we have to look into the whole product life cycle including material selection, production, packaging, transportation, usage and disposal.
  - KPI-6 Resin
  - KPI-7a Printing Inks and Solvents – RoHS Compliance
  - KPI-7b Printing Inks and Solvents – Volatile Organic Compound (VOC) Contents
  - KPI-8 Resin Consumption Reduction
  - KPI-9 Design Methodology (for ODM & OEM Products)

## 4.4 Key Performance Indicators (KPIs)

As mentioned in the previous paragraph, there are totally nine key performance indicators for the assessment scheme. There may be more specific performance indicators for measuring a company's environmental related performance. The selected performance indicators are only part of the possible indicators which are considered as critical, minimum, basis and useful for comparison among different companies.

- **Category 1 - Energy Management**

  The indicators inside this category evaluate the efficiency of energy consumption inside the factory.

- **KPI-1 Critical Process Energy Consumption (kWh/kg)**
  - Film extrusion is considered to be the critical energy consumption process in plastic bag manufacturing.
  - This indicator serves to compare if energy is used in an efficient way in the film extrusion process.
- **KPI-2 Workshops Specific Energy Consumption (kWh/kg)**
  - Other than extrusion, workshops consume energy in their overheads, e.g. auxiliary equipment, lighting, ventilations.
  - This indicator serves to compare if energy is used efficiently in other related plastic bag production workshops, i.e. except for plastic extrusion.
- **KPI-3 Office Energy Consumption (kWh/m²/annum)**
  - Although offices normally consumes less energy than production workshops, if everyone can do a little bit, much energy can be saved.
  - This indicator serves to compare if energy is used efficiently in the office areas.

**Category 2 - Noise Pollution**

This category serves to measure if the noise from the factory will affect the environment.

- **KPI-4 Noise Level (dB)**
  - This indicator assesses the noise level of the manufacturing plant in accordance with GB 12349-90《Method of measuring noise at boundary of industrial enterprises》and GB 12348-90《Standard on noise from industrial enterprise sites》.

**Category 3 - Management System**

This category serves to look at the measures and efforts a company puts in for environment manufacturing management. Industry norms have been established in these areas.

- **KPI-5 Environmental Management System Standards**
  - This indicator measures a company's degree of using environmental management practices or standards.
  - Adoption of international recognized environmental management standards is well accepted as an independent and objective measure of the environmental management level of a company.

## Category 4 - Product Design

This category serves to look at the measures and efforts a company puts in for environmental product design.

- **KPI-6 Resin**
  - Resin is the major material of a plastic bag. When selecting green resins, the following criteria are identified as the most critical:
    - RoHS Compliance or equivalent
    - Renewable materials (e.g. PHA, PLA)
    - Degradable materials (Bio-/Photo-/Hydro-/Oxo-degradable)

- **KPI-7a Printing Inks and Solvents – RoHS Compliance**
  - The major concerns over printing inks are its contents of hazardous substance. When selecting green materials, the following criterion is identified as one of the most critical:
    - RoHS Compliance

- **KPI-7b Printing Inks and Solvents – Volatile Organic Compound (VOC) Content**
  - The major concerns over printing inks are its contents of volatile organic compound (VOC). When selecting green materials, the following criterion is identified as one of the most critical:
    - VOC Contents

- **KPI-8 Resin Consumption Reduction**

  — When designing a green plastic bag, 3R concepts: Reduce/Reuse/Recycle can be applied to save resources. The following methods are identified as some practical applications to reduce the use of virgin materials:

    - Use of recycled resin
    - Use of Calcium Carbonate (CaCO3) as fillings
    - Use of metallocene catalyst to improve the strength of plastic bag

- **KPI-9 Design Methodology (for ODM & OBM Products)**

  — When designing a green plastic bag, the following criteria are identified as the most critical:

    - Application of advanced ecodesign tools into product design
    - Acquirement of Certification / Green / Biodegradable / Compostable Marks

## 4.5 Performance Grading System

This plastic bag manufacturing industry green production benchmarking model is an industrialized model. “Grade 0” is the poorest practice while “Grade 5” is considered as the world’s best industrial practice. Considerations should be taken for errors in data capturing and therefore the auditor should exercise his/her professional judgement in determining the most appropriate grade if the data fall between 2 grades.

For detail assessment and grading methods, please refer to the guidebook of “Green Production Assessment Scheme for Plastic Bag Manufacturing Industry”

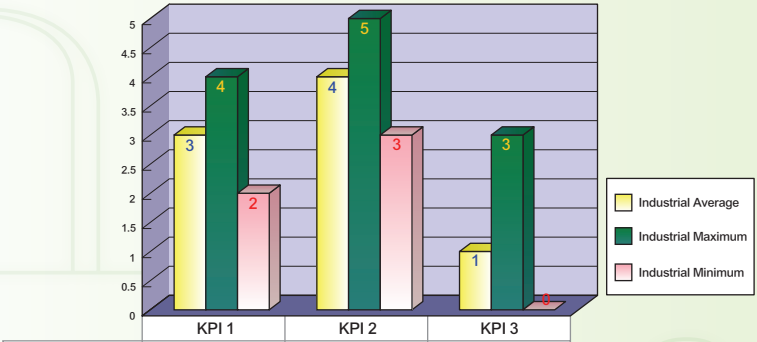
# Chapter 5

# Green Production Assessment Benchmarking Data Analysis for Local Industry

Chapter 5

# Green Production Assessment Benchmarking Data ANALYSIS for Local Industry

## 5.1 Category 1 – Energy Management




| | KPI 1 | KPI 2 | KPI 3 |
|---|---|---|---|
| Industrial Average | 3 | 4 | 1 |
| Industrial Maximum | 4 | 5 | 3 |
| Industrial Minimum | 2 | 3 | 0 |

### KPI-1 Critical Process Energy Consumption (kWh/kg)

***Film extrusion is considered to be a critical energy consumption process in plastic bag manufacturing. This indicator serves to compare if energy is used in an efficient way in the film extrusion process.***

During the assessment, it was found that none of the companies installed individual power meter for the critical processing machines – extruders. And they did not keep comprehensive

records of the production throughputs of each extruder. Thus, some specific estimation and assumption were done for analysis purpose.

The industrial average grading for this KPI was only 3, indicating that there are still rooms for improvement for the critical process energy consumption. More attention should be put on the energy efficiency of the extrusion blow moulding process through:

- Selecting the right extruder for the job
- Running the extruder efficiently
- Matching the supply of utilities to the actual demand
- Matching the electric motor size to the actual duty
- Measuring energy performance
- Improving the maintenance practices, etc.

## KPI-2 Workshops Specific Energy Consumption (kWh/kg)

***Other than extrusion, workshops consume energy in their overheads, e.g. auxiliary equipment, lighting, ventilations, etc., which should not be neglected.***

For this KPI, the industrial average grading was 4, indicating that the companies did try some ways to save workshop energy consumption but further improvement measures or more energy efficient devices could be adopted.

Since most factories have been constructed for over 10 years, energy saving facilities or features were not incorporated into the building design. Most factories have installed simple energy efficient devices though, e.g. water-cooled ventilation system, eco-air conditioner, T8 industrial lighting, etc. And they also replaced over-capacity auxiliary equipment to reduce energy consumption.

Companies should have a comprehensive plan for installing these kinds of energy efficient devices. As the energy cost is getting high, these kinds of devices will become more cost effective. They should also evaluate the feasibility of installment of some advanced devices, e.g. solar power system such as photovoltaic panels/systems, heat-recycling system, water-recycling system, etc., to save resources in all possible means.

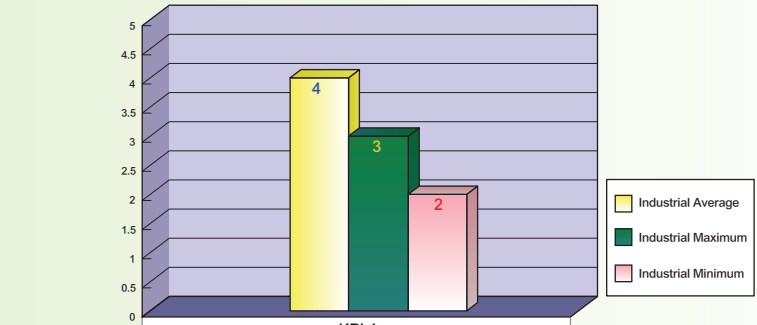
## KPI-3 Office Energy Consumption (kWh/m²/annum)

***Although offices normally consume less energy than production workshops, if everyone can do a little bit, much energy can be saved.***

During the assessment, it was found that none of the companies installed individual power meter for the office areas and therefore no records were kept for this kind of analysis. Thus, some specific estimation and assumption were done for analysis purpose.

For this KPI, the industrial average grading was 1, indicating that there are many improvement areas. Though most companies have set up housing keeping practices for their staff to follow, further monitoring measures should be taken and power consumption records should be kept for regular evaluation of the improvement. To save energy, when replacing old appliances, e.g. computers, printers, air-conditioners, etc., energy labelled appliances are recommended. Whenever possible, make use of natural light. Otherwise, energy efficient T5/T8 fluorescent lamps should be considered. Automatic illumination controlling systems/devices and multi-zone separate lighting control systems are recommended as well.

# 5.2 Category 2 – Noise Pollution



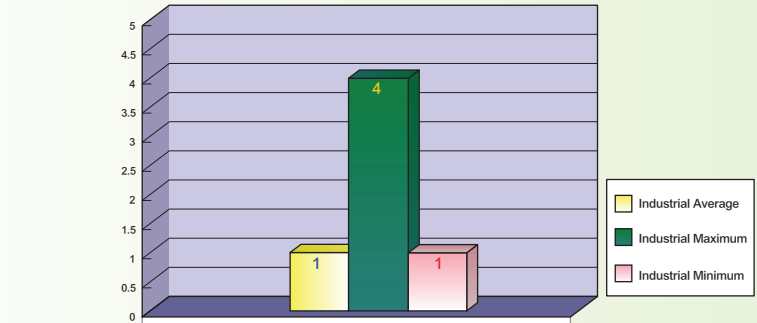

| | KPI 4 |
|---|---|
| Industrial Average | 4 |
| Industrial Maximum | 3 |
| Industrial Minimum | 2 |

## KPI-4 Noise Level (dB)

***Plastic bag manufacturing plant operates 24 hours a day, 7 days a week. The noise from the manufacturing plant may disturb the activity or balance of human or animal lives.***

During the assessment, it was found that the noise pollution problem was negligible. The noise from the factories basically did not affect the areas outside the boundary of the plastic bag manufacturing plants. The noise level measured was basically the background noise. If the factory is located beside the highway, then the noise level measured will be higher while if the factory is located beside the farm areas, the noise level measured will be lower.

# 5.3 Category 3 – Management System




| | KPI 5 |
|---|---|
| Industrial Average | 1 |
| Industrial Maximum | 4 |
| Industrial Minimum | 1 |

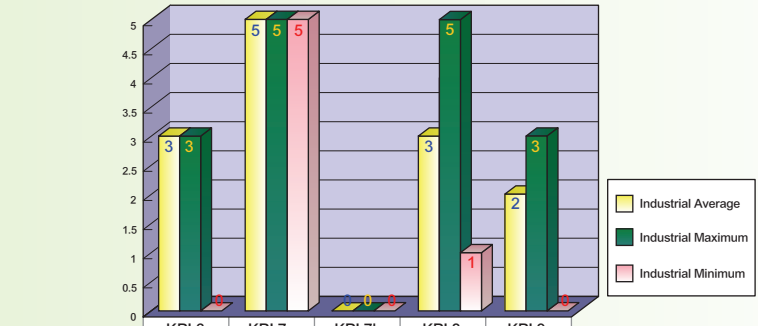
## KPI-5 Environmental Management System Standards

***A comprehensive environmental management system can help the company to maintain a good environment performance.***

For this KPI, the industrial average grading was 1, indicating that the adoption level of the environmental management system, e.g. ISO14001, and some tools, e.g. continuous improvement programs, were low. Most companies have set up some simple green procurement policies but might not be comprehensive enough. They should review their purchasing practices to produce more specific ones and define a more comprehensive supplier assessment plan. Continuous improvement programs should be run in a more systematic way as well so that feasible improvement suggestions can be raised in a proper channel and worked out successfully.

Since ISO 14001 is internationally recognized as an objective measure of the company's environmental management level, companies should not view it as a burden but consider it as an useful tool for guiding them to be a green producer and an honour to better promote their products and companies.

# 5.4 Category 4 – Product Design




| | KPI 6 | KPI 7a | KPI 7b | KPI 8 | KPI 9 |
|---|---|---|---|---|---|
| Industrial Average | 3 | 5 | 0 | 3 | 2 |
| Industrial Maximum | 3 | 5 | 0 | 5 | 2 |
| Industrial Minimum | 0 | 5 | 0 | 1 | 0 |

## KPI-6 Resin

***Plastic resin is the major raw material of a plastic bag. Producers should consider the following features to the greatest extent when selecting resins:***

— ***RoHS Compliance or equivalent***

— ***Renewable (e.g. PHA, PLA)***

— ***Degradable (Bio-/Photo-/Hydro-/Oxo-degradable)***

It is a market driven world. Manufacturers, to a large extent, manufacture according to demands. For this KPI, the industrial average grading was 3, indicating that the demand of green resins in the market was still not strong enough. Manufactures were not motivated strongly enough to adopt the use of green resins.

RoHS compliance seems becoming a basic environmental requirement. Most companies understand the RoHS requirements but their compliance certificates collection and keeping system still needs improvement. Due to the high cost, renewable materials, e.g. PHA and PLA, are not popular in the market. It is unsurprised that the application rate is low. However, as

the degradable plastic market is growing, companies should take the chance to produce more degradable products which are considered to be more environmentally friendly.

## KPI-7a Printing Inks and Solvents – RoHS Compliance

***The major concerns over printing inks and solvents are their contents of hazardous substance. Producers should consider "RoHS Compliance or equivalent" in the greatest extent when selecting printing inks and solvents.***

For this KPI, the industrial average grading was 5. All the assessed companies adopted the use of RoHS compliance printing inks and solvents for their production. This shows that the requirement of RoHS compliance printing inks and solvents is well accepted in the industry, most possibly due to the requirements of the safety regulations of exporting countries. Although most companies understand the RoHS requirements, the compliance certificates collection and keeping system still needs improvement.

## KPI-7b Printing Inks and Solvents – Volatile Organic Compound (VOC) Contents

***The major concerns over printing inks and solvents are their contents of harmful volatile organic compound (VOC). Producers should take this into serious consideration when selecting printing inks and solvents.***

For this KPI, the industrial average grading was 0, indicating that the awareness of the producers to VOC contents was insufficient and they were not motivated by the market to use low-VOC printing inks and solvents.

Many countries have identified VOCs as sources of air pollution. Regulations have been set up to limit the VOC contents of paints and inks. It is believed that Mainland China will come up similar rules in the near future. Therefore, companies are recommended to get rid of solvent based inks and adopt low-VOC inks such as water-based, oil-based, soya-based printing inks, etc., as soon as possible. Otherwise, they should consider installing VOCs removal systems

to avoid the emission of VOCs into the environment or VOC recovery systems to recycle the VOCs produced.

## KPI-8 Resin Consumption Reduction

***When designing a green plastic bag, 3R concepts (Reduce, Reuse, Recycle) can be applied to save the use of materials. The producers may consider the following as some practical applications to reduce the use of virgin materials:***

— ***Use of recycled resin***

— ***Use of Calcium Carbonate ($CaCO_3$) as fillings***

— ***Use of metallocene catalyst to improve the strength of plastic bag***

For this KPI, the industrial average grading was 3, indicating that the companies did put efforts in finding ways to reduce the use of virgin materials. This can help the environment in one way, while in the other way, save costs.

All the companies fully recycle their scraps and apply them into production. However, limited supply of reliable recycled resin has limited their applications. Companies should try to apply Calcium Carbonate and metallocene catalyst to the greatest extent, considering different product specification and applications.

## KPI-9 Design Methodology (for ODM & OBM Products)

***When designing a green plastic bag, the producers should consider making use of some ecodesign tools and taking into accounts the requirements of some existing green labels and certification schemes.***

For this KPI, the industrial average grading was 2, indicating that ecodesign and eco-product were still new concepts to them.

In most case, the plastic bag producers do not design the appearance of the bag, rather, they design the formulation. They design by experience without a systematic record of the design

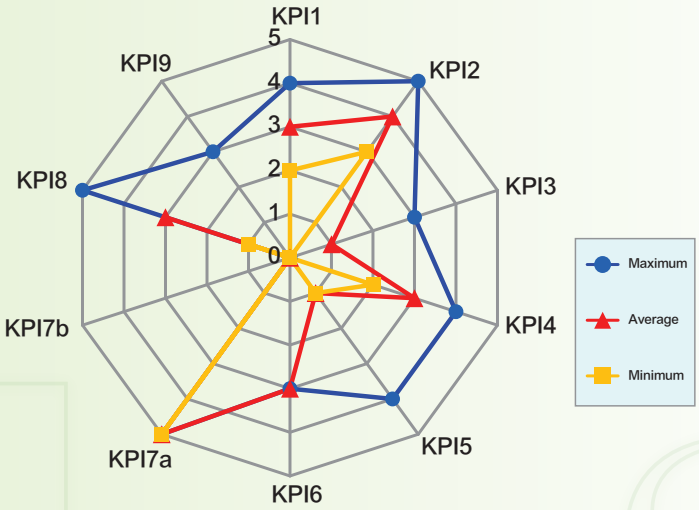
logic and the knowledge behind. These lead to a problem that some environmental features or considerations, e.g. green materials application, design for weight reduction, design for reuse, design for recycle, may be missed in the design phase. When talking about ecodesign tools, it does mean a large scope. Since the plastic bag product design and manufacturing are relatively simple as compared to other industries, it is recommended that the companies start from tailor-making a comprehensive ecodesign checklist among their product development teams.

Green labels and certifications are still not common for plastic bag products nowadays. It is not surprising that the adoption rate is low. However, the criteria and guidelines set in the green labels and certification schemes are worth studying and maybe inspiring when developing the ecodesign checklist.

## 5.5 Summary

*Plastic Bag Manufacturing Industry*

*KPI Overall Summary and Analysis*




- KPI-1 Critical Process Energy Consumption (kWh/kg)
- KPI-2 Workshops Specific Energy Consumption (kWh/kg)
- KPI-3 Office Energy Consumption (kWh/m²/annum)
- KPI-4 Noise Level (dB)
- KPI-5 Environmental Management System Standards
- KPI-6 Resin
- KPI-7a Printing Inks and Solvents – RoHS Compliance
- KPI-7b Printing Inks and Solvents – Volatile Organic Compound (VOC) Contents
- KPI-8 Resin Consumption Reduction
- KPI 9 Design Methodology (for ODM & OBM Products)

# Chapter 6

# Best Operation Practices (Local & Overseas)

Chapter 6

# Best Operation Practices (Local & Overseas)

During the evaluation of the "Green Production Assessment Scheme" conducted for the pilot plastic bag manufacturing companies, a number of best or good operation practices from some of the pilot companies were collected. By taking the reference of the practices from some renowned overseas plastic bag producers, a list of best operation practices (local & overseas) worthwhile as references for local plastic bag manufacturers are consolidated in this section.

## 6.1 Category 1 - Energy Management

### Energy Efficient Thermoplastics Extrusion

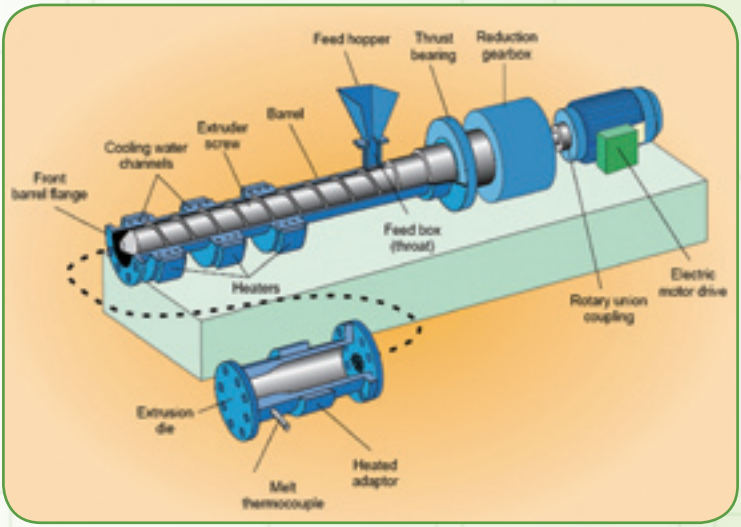



*Figure 6.1 Typical structure of an extruder*

Film extrusion is considered to be a critical energy consumption process in plastic bag manufacturing. More effort should be paid to improve the energy efficiency so as to achieve the most economical result. Figure 6.1 shows the basic structure of an extruder. The main components of an extruder are:

— An electric variable speed drive, usually driven by a DC electric motor;

— A reduction gearbox with robust end-thrust protection;

— A barrel and screw system; and

— A die system designed to form the melted polymer into the required shape or section.

Central to the extruder is a rotating screw inside a close-fitting barrel. Polymer, in powder or granular form, is introduced to the barrel via the hopper and conveyed along the flights of the screw to the die assembly at the other end. The polymer is melted (or softened) by electric heaters on the outside of the barrel and die assembly, and by the mechanical action of the screw, which also provides the pressure to force the polymer through the die.

For most common applications, extruder screws range from 30-90 mm diameter with an output of 30-600 kg/hour. The installed power of the drive and heater ancillaries range from 15-60 kW. Where a second polymer is co-extruded, smaller machines down to a 15 mm screw may be used. The ratio of screw length to diameter (L/D) is typically 25:1 or greater, although too high a ratio can cause wear and vibration problems because the screw is only supported at one end by thrust bearing.

Below shows some energy saving opportunities for the extruder for reference. Most of the measures suggested are 'Common-sense' operation which can be implemented immediately without the need for capital investment. For a better understanding of energy use, it is important to measure energy performance, i.e. identify where energy is wasted and target effort and resources at the most cost-effective opportunities.

◆ **Select the right extruder for the job**

The main function of the extruder screw and barrel is to deliver polymer to the die under pressure and in an appropriate physical state. The polymer must be heated and subjected

to mechanical shear to ensure it flows correctly through the die. There is a crucial balance between heat supplied externally (by the barrel heaters) and that generated internally (by the mechanical action of the rotating screw). The process is generally more efficient when the bulk of the energy is supplied internally. Two key factors affecting the balance are the screw/barrel diameter and the screw design.

*Screw/Barrel Diameter*

**DO NOT use a machine just because it is convenient.**

**DO NOT use large diameter extruders for small cross-section profiles.**

The extruder screw becomes more efficient as it approaches its design rotation speed which equates to a design linear speed of polymer in the barrel, depending on the design of the screw. The linear speed of polymer in the barrel ($S_B$) is roughly related to the linear speed of the extrudate ($S_E$) by:

$$(S_B) \approx (S_E) * A_E/A_B$$

where: $A_E$ = cross-sectional area of the extruded profile

$A_B$ = average cross-sectional area of the cavity between extruder screw and barrel

The polymer type, product profile design and capacity of the downstream auxiliaries impose a maximum limit on $S_E$, either because the handling equipment cannot cope with high values or because product quality would degrade due to deformation of the soft, hot extrudate possibly as a result of limited cooling capacity.

From the above equation, the upper limit on SE imposes an upper limit on $S_B$, such that it is low where $A_E/A_B$ is small, i.e. the extruder screw/barrel diameter is large compared with the extruded profile cross section. A low value of $S_B$ therefore means a low rotational speed and wasted energy.

*Check:*

— The screw diameter – is the machine oversized?

— The screw design – is it right for the polymer and product?

◆ **Run the extruder efficiently**

The pitch of the screw determines the relationship between rotation and linear motion, which interacts with the design of the screw profile and spacing between flights to produce the shear forces applied to the polymer. Screw design cannot be considered in isolation: how it affects the operation of the extruder depends on the polymer properties, the product section and the die used. An extruder can be operated to give acceptable product with a wide range of profile sections and polymers, but its efficiency will decrease as it operates further from the design conditions for the screw.

*Check:*

— Machine speed – is the extruder run at its most efficient (usually maximum design speed)?

— Machine running – are barrel heaters and cooling fans left on between runs?

— Temperature – what temperature does the polymer actually need?

— Motor drives – is the electric motor oversized?

— Wear and tear – is energy use monitored (to identify deterioration) and is action taken?

◆ **Match the supply of utilities to the actual demand**

*Check:*

— Cooling water – is it circulating wastefully through idle machines?

— Cooling water – is it at the maximum temperature and minimum quality needed by the process?

— Cooling water - is it treated, chilled and distributed efficiently?

— Compressed air - is it supplied to idle machines?

— Compressed air - is it supplied at the minimum pressure and quality needed by the process?

— Vacuum – is it at the minimum needed by the process?

— Vacuum – is it generated and distributed efficiently?

— Building services - are lighting and ventilation left on around unmanned/ idle machines?

- **Match the electric motor size to actual duty**

Although it is seldom cost-effective to replace oversized motors with new, smaller motors, retrofitting suitable motors from spares stock could reduce energy bills. It is suggested to identify the ideal motor size for each piece of equipment, and to ensure any replacements, e.g. if motors burn out, are of the correct size.

- **Maintain auxiliary and utility equipment**

*Check:*

— Mechanical wear and tear

— Quality of insulation

— Leaks and restrictions in distribution systems

— Deterioration in the electrical properties of motors and heaters

— Calibration of sensors and control systems

- **Measure energy performance**

- **Quick Reference Checklist**

## Energy Reduction Through Improved Maintenance Practices

Energy reduction through improved maintenance practices is composed of 9 distinct areas in which ineffective maintenance practices adversely affect energy consumption. The below discussions provide a starting point from which to evaluate and address in-house maintenance concerns that result in excessive energy consumption.

Friction can be classified as the maintenance department's single largest enemy. Friction causes heat which in turn causes wear, which directly impacts energy consumption levels; the more the friction is present in a piece of machinery, the greater the energy requirement to operate

the machine. A major responsibility of any maintenance department is to ensure that heating, cooling, and generated power systems (compressed air and steam) are operating at a level no less than the original minimal design efficiency level, and to ensure that losses relating to ineffectiveness and energy waste are under the direct control of maintenance. In this situation, maintenance retains a direct link to energy use effectiveness and is viewed as a major player in the effective reduction of energy waste.

### ◆ Lubrication

Effective lubrication uses the correct lubricant delivered at the correct time to effectively reduce energy consumption. The amount of savings attained depends upon existing losses due to friction, wear and ineffective lubricant delivery. Successful examples of effective lubrication have documented energy saving in excess of 20%.

Aside from energy savings, other large saving areas are accrued through reduced downtime, reduced lubricant change-outs, and increased equipment life.

**Quick Tips:**

- ✔ Perform a lubrication effectiveness review to determine areas of effectiveness and, more importantly, areas of opportunity. Lubrication effectiveness studies are best performed by a third party consultant experienced in lubrication and maintenance management who is able to offer a third party unbiased assessment of present conditions.
- ✔ Determine lubrication requirements for all lubricated equipment. Reference to lubrication handbooks or employ lubrication consultants or lubricant manufacturers.
- ✔ Consolidate lubricant requirements.
- ✔ When in doubt, refer to equipment manufacturer's guide for the correct lubricant or lubricant equivalent to use.
- ✔ Develop a clear policy for purchasing and lubricant storage by indicating how and where lubricants are to be used.
- ✔ Change-out lubricants based on actual usage patterns rather than OEM generic recommendations. Use oil analysis to determine the appropriate change-out intervals.

- ✔ Investigate the use of premium and synthetic lubricants for optimum cost effectiveness.
- ✔ Perform an energy-use analysis before and after lubrication changes to determine the actual program savings.

### ◆ Compressed air systems

In a typical compressed air system, 25% of consumed energy is wasted due to system inefficiency. Improperly designed and maintained systems reflect this inefficiency through:

- ✔ Decreased compressor performance
- ✔ Compressed air leakage
- ✔ Distribution system pressure drop

Like all equipment, compressed air systems need to be well designed and maintained in order to run efficiently. Compressors need to be matched to a plant's operating requirements as well as to the plant's ambient conditions. Regardless of the system design, by using effective maintenance practices, existing energy costs can be significantly reduced by over 25%.

**Quick Tips:**

- ✔ Perform a compressed air audit study to determine energy saving opportunities.
- ✔ Perform air leak checks as a regular part of a preventive/ predictive maintenance program.
- ✔ Use a synthetic compressor lubricant when appropriate. It will reduce energy consumption and extend lubrication change-out interval time by up to five times.
- ✔ Wherever practical, use electric motors rather than air motors, electrical control rather than pneumatic control, electrical tools rather than air tools. Compressed air devices use four times the electricity of electrical devices.
- ✔ Ensure compressed air filter checks and changes are a regular component of the preventive maintenance program.

### ◆ Electrical connectivity

When sized and tightened correctly, electrical connections will provide the equipment owner with good connectivity and a trouble free operation requiring little maintenance. However, neglect in these two areas can constitute a fire safety hazard, which can cause unnecessary energy expenditure. A simple loose connection can represent thousands of dollars in wasted profit.

**Quick Tips:**

- ✔ Use infrared thermography to measure the electrical connectivity can significantly reduce maintenance and inspection time and can be performed while the equipment is in operation.
- ✔ Always torque electrical connections to the manufacturer's recommended specifications.
- ✔ Check electrical insulation visually for heat cracks and wear and replace immediately if suspect.
- ✔ Check for looseness or mechanical wear on electrical contactors. Tighten and replace only components which require this maintenance.
- ✔ Check for even and full contact on fuses and knife-gate contacts.
- ✔ Check for relay chattering (relay repeatedly tries to make full contact and is unsuccessful; this is often due to dirty contacts).
- ✔ Check for and report unusual noises and smells.

### ◆ Mechanical drive systems

Mechanically driven transmission systems transmit electrically developed energy from an electrical motive device to a driven device via a selection of mechanical devices such as couplings, gears, belts, chains and cams, linkages, clutches, brakes, etc. The mechanically driven transmission functions to vary the torque speed or position from the motor shaft to the connected driven machine.

Laser alignment equipment manufacturers claim that improved alignment of shaft-coupled rotating equipment has been measured to produce electrical energy savings of up to 11% while increasing the longevity of the mechanical couplings, gears, bearings, etc., by up to 8 times.

**Quick Tips:**

- ✔ Ensure belts and chains are tensioned properly at all times.
- ✔ Investigate automatic tensioning adjusters (spring loaded idler wheels).
- ✔ Manufacture "go, no-go" gauges for quick checks of tensioned devices. (A go, no-go gauge is a manufactured device which when placed against a reference point will indicate of the tension is within the predetermined high-low limit range).
- ✔ Ensure brakes do not trail.
- ✔ Check gearbox lubricant to ensure it is the correct viscosity. Misalignment will show up as wear and can also be determined through oil analysis.
- ✔ When equipment is properly aligned, paint marker indications of coupling arrangements and hold down bolts. If looseness or misalignment starts to occur, the markers will show up out of alignment, giving an early indication of alignment problems.

◆ **Waste heat and cooling recovery**

Heat recovery and cooling systems require engineering studies that are usually beyond the normal realm of general maintenance activities. However, more and more companies are charging their maintenance departments with the responsibility of handling the energy budget. The maintenance department must, therefore, be cognizant of these valuable energy-saving opportunities. A good maintenance practice is one which introduces a heat recovery and cooling system when conditions warrant.

With heat recovery, savings need to be determined on an individual basis. It is a relatively easy task to determine the amount of heat recovery and to cost out the heat. The project costs of capturing the heat are then applied against the savings to determine the return on investment.

Up to 94% of the heat equivalent of total electrical input can be recovered through an enclosed oil-cooled screw compressor arrangement. Manufacturers of compressed air systems offer heat exchangers for the production of hot water: these exchangers deliver hot water at a temperature range between 130°F to 160°F. Because most plants or facilities utilize compressed air systems, excellent heat recovery saving opportunities already exist for many of today's companies.

**Quick Tips**

- ✔ Use an infra red detector to check for correct operation and effectiveness of heat exchanger devices.
- ✔ Use infra red thermal imaging to check for insulation and refractory degradation.
- ✔ Once a heat recovery opportunity is identified, perform an engineering study and savings analysis to determine the best methods for return on investment before the start up of any heat recovery project. Assistance in this area is available through local utilities and consultants.

◆ **Housekeeping**

When improved housekeeping practices are put into effect, multiple savings can occur simultaneously.

| Good Housekeeping Reduces: | Saving Increased Through: |
|---|---|
| Wear Contaminants | Extended component life, extended lubricant life, reduced energy losses. |
| Product Contamination | Higher quality control, reduced energy and resource costs, associated with product reworking. |
| Component Failures | Identification of hidden defects. |
| Energy Consumption | Improved contact surfaces, heat reduction, higher efficiency cooling, reduced pressure drops through filtration media. |

**Quick Tips**

- ✔ Introduce equipment cleaning as a regular part of maintenance inspections.
- ✔ Whenever possible, place air filtration media on outside of equipment so that the condition can be easily seen and changed as required.

### ◆ Planned maintenance practices

Planned Maintenance (P.M.) is well known acronym familiar to industry, but it can be defined to mean many different things. All definitions of P.M. are similar in the sense that they all imply performance of maintenance using a positive rather than a reactive "fire-fighting" approach. Ford Motor Company performed a study in the 1980s and found that P.M. costs accounted for one-third the cost of reactive maintenance.

Poor P.M. practice can result in an unnecessary increase in energy requirements. By performing maintenance in a structured manner, unnecessary costs associated with increased energy demand and overmaintenance can be virtually eliminated.

**Quick Tips:**

- ✔ Check present planned maintenance instruction sets for ambiguity.
- ✔ Ensure task definitions are concise, descriptive, and relevant.
- ✔ Whenever possible, number the steps involved, giving "if" and "then" options to facilitate the process.
- ✔ Refer to and note actual specifications within the planned maintenance task.
- ✔ Always produce feedback reports. For example, how well equipment performed as a result of the planned maintenance; energy usage prior to and post planned maintenance.

### ◆ Industrial lighting

Lighting is an important aspect of any workplace because correct lighting levels are crucial for good work performance and work place safety. The type of lighting used depends upon the task or activity performed within the specific workplace area. In the industrial work place, there are 3 types of lighting presently in use: incandescent, fluorescent and high intensity discharge (sodium, metal halide, mercury vapour).

When considering the energy efficiency of the lightings, fluorescent lights are 3 times more efficient than incandescent lights while HID lights are up to 2.5 times more efficient than fluorescent. Other than concerning the light sources, fluorescent fixtures can be made more efficient by installing a mirror-like retrofit reflector polished and angled to increase the light refraction more efficiently than a standard reflector. In places where existing light levels are low, reflectors can increase light levels by up to 15%; where light levels are too high, lamps and ballasts can be removed from the fixture, thus reducing energy consumption by up to 50% while only decreasing lighting levels by 25%. Also lamps and ballasts can be eliminated by using retrofit reflectors.

**Quick Tips:**

- ✔ Clean light reflectors and lamps on a regular basis.
- ✔ Perform a lighting management study to determine exact lighting requirements and potential energy savings opportunities.
- ✔ Replace incandescent lamps with compact fluorescent lamps as lamps burn out; energy use is 80% less and the lamp lasts four times as long with only a one-year payback.

*(Source: "Energy Reduction Through Improved Maintenance Practices; Kenneth E. Bannister")*

### Energy Efficiency and Conservation to Buildings and Offices

- Sustainable Resources
- Space Planning
- Building Material
- Building Orientation
- External Shading Device
- Building Envelope
- Electrical Installation
- Lighting Installation
- Small Power and Office Equipment
- Air Conditioning Installation
- Lift Installation and Escalator Installation
- Plumbing and Drainage Installation

## 6.2 Category 2 – Noise Pollution

Since plastic bag manufacturing is a light industry, the noise produced by the factory is negligible and basically does not affect the areas outside the boundary.

However the noise level inside some workshops, e.g. extrusion workshop, printing workshop is high. It is recommended that all workers should wear protective devices to protect their ears as a compulsory practice.

## 6.3 Category 3 – Management System

- **Green Procurement Policies**
- **Environmental Improvement Programs**
- **ISO 14001**
- **Other environmental management systems, e.g., ISO 14062, QC080000, etc.**

## 6.4 Category 4 – Product Design

- **Green Plastics**
  - RoHS compliance or equivalent
  - Renewable plastics
  - Biodegradable plastics
- **Green Printing Inks and Solvents**
  - RoHS compliance or equivalent
  - Low VOC printing inks and solvents
    - Water-based printing inks
    - Oil-based printing inks
    - Soya-based printing inks
  - VOC removal/recycle system
- **Resin Consumption Reduction**
  - Recycled resin application
  - Use Calcium Carbonate ($CaCO_3$) as fillings
  - Use metallocene catalyst to improve the strength of plastic bag

## Design Methodology (for ODM & OBM Products)

- Applying ecodesign tools
  - Environment Impact Assessment Table
  - Philips Fast Five Checklist
  - Life Cycle Analysis (LCA)
  - Analysis Checklists
  - Ecodesign Checklist

- Understanding the product criteria required for local and overseas Green Certifications/ Green Marks/ Biodegradable and Compostable Marks
  - Degradability/Compostability qualified by recognized standard (e.g. ASTM D6400/ EN13432 / DIN V 54900)
  - THE COMPOSTABILITY MARK OF EUROPEAN BIOPLASTICS AND DIN CERTCO
    *(Source:http://www.dincertco.de/en/about_us/our_marks_of_conformity/the_compostability_mark_of_european_bioplastics_and_din_certco.html)*
  - EPD - Registration Scheme for Degradable Containers and Bags
    *(Source:http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/guide_intro.html)*
  - HK Green Label Scheme – Product Environmental Criteria for Degradable Non-Food/Drink Containers and Non-Food Bags (GL-005-006)
    *(Source: http://www.greencouncil.org/eng/doc/GL005006.PDF)*
  - Other worldwide Green Label Schemes
  - North America (Environmental Choice(Ecologo)/ Germany (Blue Angel)/ USA (Green Seal)/ Japan (Eco Mark) / New Zealand (Environmental Choice New Zealand)
    *(Source: http://www.gen.gr.jp/product_link.html)*

# 第一章

# 概要

# 第一章

# 概要

針對綠色塑料袋業之綠色生產評估計劃，我們制定了一套涵蓋整個塑料袋和包裝的生命週期的綠色生產評估準則。這些準則根據以下四個類別定出來，分別：能源管理，噪音污染，管理系統及產品設計。

在五間作為試點的塑料袋製造公司的支持與合作下，我們已成功收集了一些行業的日常生產及運作模式，從而獲悉本地行業的普遍營運慣例。

從能源管理方面，現時工業的平均等級為2.7，為一個尚可接受的級別。事實上，這方面還有很多地方是需要改善的。而噪音污染方面，工業平均等級為3，相對現時的標準來說，這也屬於一個尚可接受的等級。然而，我們發現主要噪音是來自廠外周圍環境所致的，因此行業對噪音控制實際上處理得不錯。管理系統方面，現時平均等級為1。從資料顯示，相對其他行業，塑料袋製造業對實施環保製造管理(如其他行業較廣採用的ISO14000)的做法並不普遍。至於產品設計方面，現時的平均等級為2.6。實際上，這行業尚欠誘因去推動設計一些環保的產品。不過，從環保角度上，他們已開始選用於不同材料或添加劑以取代或減少使用一些原材料。

從評估結果顯示，如塑料袋製造業想成功轉化成為綠色生產工業，在多方面還是有很多地方須要改進的。這本書會提供一些簡單及快捷的提示，希望製造商可以跟從建議。這些建議可能已廣為人知，但卻甚少切實執行。其實，在日常工作上每一個小地方的改善，也可使廠房在綠色生產表現上有一個大改進。

# 第二章

# 塑料袋製造及物料

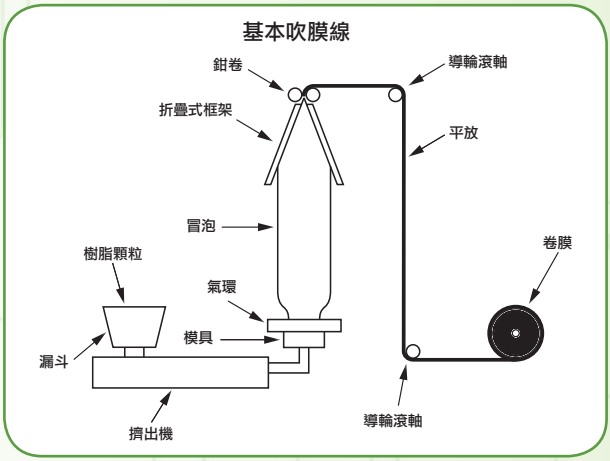
# 第二章

# 塑料袋製造及物料

## 第一節　塑料袋製造

製造塑料袋先要生產塑料薄膜。首先要將塑膠粒加熱融化，融膠以一定的速度流過定型模具，經冷卻後捲入滾筒，收集成為塑料薄膜。事實上，許多不同變化和複雜的工序都可加插到這個製程。製作薄膜後，可用不同方法如印刷、成型、塗層、複合、沖壓、分切、成型和折疊等來為塑料薄膜增值，製成塑料袋。

### 吹膜擠出（吹膜）技術

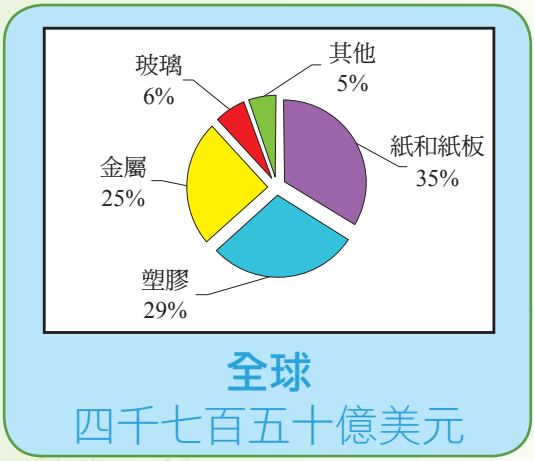



*(Source: http://plastics.turkavkaz.ru/processes/extrusion/blown-film-extrusion/)*

# 第二節　薄膜及材料類型

對數以百萬計的工業或消費品 —— 由化學品到家庭和個人護理產品、食品、醫療設備、飲料和其他各式產品而言，包裝是一個在功能上、外觀上及保護上不可缺少的元素。

無論在功能上及經濟因素上，塑料對於包裝行業來說均扮演著一個相當重要的角色。因為塑料成本低，重量比傳統材料輕，而且具有卓越的功能，因而越來越多人採用。




*(Source: Transdisciplinary Approaches to Waste Management: Theme: Consumers and Supply Chains Cardiff, Wales, 18th March 2004)*

很多不同種類的塑膠材料均可製成薄膜：

- 聚乙烯、高密度（聚乙烯）、低密度（聚乙烯）和線性低密度（聚乙烯）
- 聚丙烯、單一導向（聚丙烯）、雙向（聚丙烯）和 聚丙烯鑄膜
- 聚氯乙烯

- 聚苯乙烯和導向聚苯乙烯
- 不飽和聚酯、聚乙烯苯二甲酸乙二醇酯
- 乙烯醇
- 聚乙烯醇
- 聚偏二氯乙烯
- 聚胺（尼龍6、尼龍11、尼龍12）
- 聚碳酸酯
- 纖維素、玻璃紙
- 利用上述的各種薄膜製成的多層塑料薄膜，包括全塑料或塑料與其他材料，如紙張、紙板和鋁箔等復合製成的多層塑料薄膜

不同塑膠原材料製成的薄膜，其特質及功能有著很大分別，可從以下數點作出分別：

- 一般商品與專業高性能材料
- 單層或單一材料與多層或複合材料
- 基本基層材料與加強附加值材料
- 包裝與非包裝應用
- 利用主工序或二次加工製成的塑膠薄膜
- 各類成品

***在這個項目中，我們只會把重點放於單層聚丙烯和聚乙烯塑料袋。***

## 聚乙烯（ PE ）

聚乙烯薄膜是最為廣泛使用的，約佔塑料薄膜的總噸量的75-80%。

由於聚乙烯在其線性分子鏈有較長的分支，此結構減低了他的結晶度。透過醋酸乙烯酯及丙烯酸乙酯的共聚作用，可進一步減低其結晶度。低密度聚乙烯擁有著高的柔韌性、高衝擊強度、脆性溫度較低、滲水性較低，而且薄膜透明度高和加工性能良好。

線性低密度聚乙烯的分子結構中沒有長鏈分支，所以密度主要是決定於共聚物的類型和數量，而密度範圍則在0.915至0.935之間。由於線性低密度聚乙烯的結晶度高於低密度聚乙烯，其樹脂熔點亦提高了攝氏10至15度。

高密度聚乙烯是以短鏈分支的線性分子結構所組成。高密度聚乙烯通常有70%的結晶度，密度為0.941-0.965，它在所有聚乙烯中擁有最好的阻隔性和強度特性。高密度聚乙烯的價值在於它的高剛度、強度和耐熱性。再者，高密度聚乙烯是一個非常好的絕緣體，對水和氣體的滲透性低。

茂金屬聚乙烯（mPE）是近年來最新列入聚乙烯系列之成員。茂金屬被稱為“智能催化劑”，因為它能夠利用精確加工來控制樹脂的具體特性。茂金屬是在1990年代初期誕生的，起初，由於茂金屬數量稀少並很難處理，以致價格昂貴。自1997年以後，新一代的茂金屬已經大為改善，它的出現大大改變聚烯烴及其他塑料。

## 聚丙烯（ PP ）

丙烯分子聯繫在一起，並形成聚合物鏈，因此被稱為聚丙烯。聚丙烯有幾種基本的類型，包括單一聚合物，共聚合物(由兩個或三個聚合物組成)和改性樹脂。

聚丙烯薄膜能阻隔濕氣、氣味及味道，並具有良好的清晰度和良好的熱密封性能。而且，聚丙烯薄膜的成本相對較低，而且重量輕（密度為0.91g/$cm^3$，是所有主要塑料中最輕的）及容易生產。因此，聚丙烯薄膜已成為全球增長最快的薄膜，不僅取代了舊的玻璃紙(cello)，而且更開闢了新的塑料薄膜市場。

# 第三章

# 降解測試

# 第三章

# 降解測試

近日，塑料袋構成的嚴重環境問題引起關注。因此，聲稱可降解的塑料袋便成為進入塑料袋市場的最大誘因。然而，真正的問題是，究竟可降解塑料袋可以降解至何種程度，從而減少廢物堆填區的負擔呢?

現時，有幾個國際公認的測試標準可核查塑料袋的降解能力和堆肥能力，它們分別是：

主要降解 / 堆肥能力的測試標準：

ISO 14855

EN 13432 (歐盟)

DIN V54900-1 (德國)

ASTM D 6400 (美國)

GreenPla (日本)

AS4736 (澳洲)

1999年，環保署與香港塑膠科技中心、香港檢定協會、消費者委員會、香港科技大學、食物環境衛生署和貿易代表成立了一個工作小組，制定一項以測試當地可降解容器和塑料袋的指引。測試指引是參照有關國際測試的方法和標準，並加以適當考慮其可降解材料的本身特點和當地環境。該指引將涉及食品安全產品測試，可降解性及物理性能的降解產品測試。生產商及供應商可委任當地的實驗室進行所需的測試。

在2000年12月，香港環境保護署（環保署）正式推行了“容器及袋的降解性及食物安全測試指引－HS2001”。它是本地開發的第一個全面性測試可降解產品指

引。它的目的是測試可降解產品對人類的健康是否安全及是否可真正降解。

該署已通知政府部門和大型食肆發出有關測試指引，以便他們能夠充分利用該測試指引，從而選擇可降解的產品。

想知道更多有關該測試準則的資料和相關的登記計劃，可瀏覽香港環境保護署的網站:http://www.info.gov.hk/epd.

*(Source:http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/guide_hs2001.html)*

# 第四章

# 塑料袋業之綠色生產評估計劃

# 第四章

# 塑料袋業之綠色生產評估計劃

## 第一節　綠色生產評估計劃

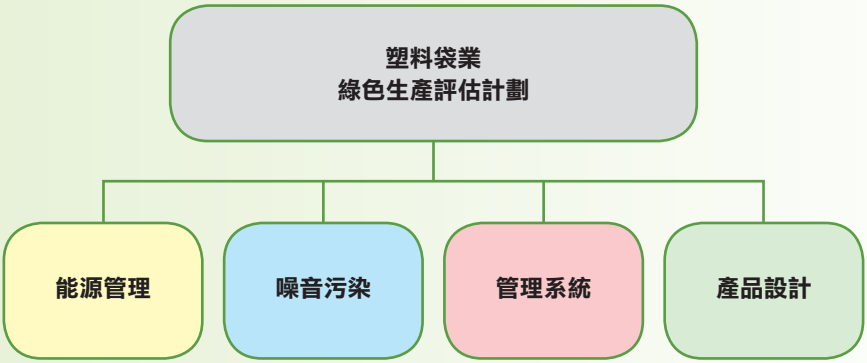
為幫助業界更了解塑料袋環保設計及生產的理念及技術上的考慮，以及改變大眾對塑料袋固有的印象，香港塑料袋業廠商會聯同香港生產力促進局早前已申請並成功獲得中小企業發展支援基金撥款資助開展了一個名為“推動與實踐有關塑料薄膜包裝之生命週期的綠色環保概念與技術”的項目。

計劃中已訂立一套涵蓋整個塑料袋和包裝的生命週期的綠色生產評估系統，作為本地塑料薄膜包裝生產商進行專業評估的指標。量度指標包括: 能源管理、噪音污染、管理系統及產品設計，目的是讚揚業界在綠色開發和生產所付出的努力及協助業界找出不足之處。

## 第二節　四個類別

『典範借鑑』是一項有系統、持續性的評估過程，透過不斷地將企業流程與世界上居領導地位之企業相互比較，以獲得協助改善營運績效的資訊，是量度及比較公司與行業之運作模式和效益的有效方法。其目的旨在向最成功的企業借鏡，尋找出「最佳運作」（Best Practices）能導向卓越成績的最佳方法，從而達到改進企業表現的目標。

塑料袋業之綠色生產評估計劃利用一套特別設計之典範借鑑模式對塑料袋生產商進行評估。計劃籌委會已針對塑料業生產特點定立了一套綠色生產評估系統，量度指標包括: 能源管理、噪音污染、管理系統及產品設計，讓參加計劃的機構了解本身在綠色生產方面的表現，確定本身的長處及缺點，以便作出持續改善。




## 第三節　各類別的定義與關係

本模式分為四個類別，共包括以下9個主要表現指標 (KPIs)，涵蓋塑料袋及包裝製造業的綠色生產主要考慮點:

- **類別 1 - 能源管理** 反映了公司的能源使用效率，有效地使用能源對保護環境及維持可持續發展有著重要的貢獻，這不但能善用地球的資源也能減少製造能源時同時產生出來的污染物。
  - KPI-1 關鍵工藝能源消耗 (kWh/kg)
  - KPI-2 工場能源消耗 (kWh/kg)
  - KPI-3 辦公室能源消耗 (kWh/$m^2$/annum)
- **類別 2 - 噪音污染** 是用作直接量度生產廠房的噪音水平，底線是產生的噪音不能影響周圍的環境。
  - KPI-4 噪音水平 (dB)
- **類別 3 - 管理系統** 反映了公司對環保的承諾及其環保管理系統的完整性。
  - KPI-5 環境管理系統標準

- **類別 4 - 產品設計** 量度公司投入於環保產品設計的努力，要決定產品是否環保，要考慮整個產品週期，包括物料選擇、生產、包裝、運輸、使用及棄置等。
  - KPI-6 塑料
  - KPI-7a 印刷油墨及溶劑 — RoHS 認證
  - KPI-7b 印刷油墨及溶劑 — 揮發性有機物(VOC)含量
  - KPI-8 塑料減用
  - KPI-9 設計方法 (ODM 及 OBM 產品)

## 第四節 主要表現指標 (KPIs)

正如先前提及，整個評估計劃共有9個主要表現指標(KPI)。要量度一間公司的環保相關表現可能涉及很多特定的表現指標，以下選取的表現指標，只是作為公司之間進行比較時為最關鍵、最基本、最有用及最可行的其中一部份指標。

### 類別 1 - 能源管理

在此類別的指標用作評估塑料袋製造活動中是否有效地使用能源。

- **KPI-1 關鍵工藝能源消耗 (kWh/kg)**
  - — 在塑料袋生產中，塑料薄膜擠出是最主要的能源消耗工藝。
  - — 這指標將比較進行塑料薄膜擠出時，能源使用是否有效。如能及時發現改善空間，將有助機構有效地節省能源。

- **KPI-2 工場能源消耗(kWh/kg)**
  - — 除了塑料薄膜擠壓工藝以外，塑料薄膜生產工場裡的其他工藝設備，如輔助設備、燈管、通風系統等亦會使用能源。

— 這指標將比較進行塑料薄膜生產時，廠房內所有與塑料袋生相關工場（不包括塑料薄膜擠壓工藝）的能源使用是否有效。

- **KPI-3 辦公室能源消耗 (kWh/m$^2$/annum)**

— 辦公室能源消耗相對地較少，但如能從小處著手，亦有助節約能源及成本。

— 這指標將比較廠房內所有辦公室的能源使用是否有效。

## 類別 2 - 噪音污染

此類別用以評估塑料袋製造廠所發出的噪音有沒有影響四周的環境。

- **KPI-4 噪音水平 (dB)**

— 這指標參考GB 12349-90《工業企業廠界噪聲測量方法》及GB 12348-90 《工業企業廠界噪聲標準》評估整個工廠範圍的噪音水平是否符合標準。

## 類別 3 - 管理系統

此類別用以檢視機構的環境改善措施和管理系統，在這方面，一些業內規範已經形成。

- **KPI-5 環境管理系統標準**

— 這指標將量度機構在環境管理標準方面的應用程度。機構採用國際認可管理標準，已被視為量度公司環境管治水平的獨立及客觀方法。

## 類別 4 - 產品設計

此類別用以評估機構在產品設計，包括物料選用以至產品生命週期方面的環境考慮是否做得足夠。

- **KPI-6 塑料**

  — 塑料是塑料袋的主要物料，其影響深遠。此指標將評估機構於選擇塑料時是否有顧及環保。以下為選擇塑料最主要的環保考慮點:

  - RoHS 認證 或 同等認受
  - 再生物料 (如 PHA, PLA)
  - 可降解 (生物 / 光 / 水 / 氧降解)

- **KPI-7a 印刷油墨及溶劑 — RoHS 認證**

  — 印刷油墨及溶劑也是塑料袋生產中的重要污染源。以下為選擇印刷油墨塑料最主要的環保考慮點:

  - RoHS 認證 或 同等認受

- **KPI-7b 印刷油墨及溶劑 — 揮發性有機物(VOC)含量**

  — 印刷油墨及溶劑也是塑料袋生產中的重要污染源。以下為選擇印刷油墨塑料最主要的環保考慮點:

  - 揮發性有機物 (VOC) 含量

- **KPI-8 塑料減用**

  — 當設計一個環保膠袋時，如能套入3R概念（減少/重用/再造），有助減少物料的使用。這指標量度機構在設定塑料配方時，有否考慮能減用塑料的方法。

  - 應用循環再造塑料
  - 應用碳酸鈣($CaCO_3$)作為充填劑
  - 應用茂金屬催化劑(Metallocene catalyst) 以增加膠袋的強度

- **KPI-9 設計方法 (ODM 及 OBM 產品)**
  - — 在設計產品時，如能應用一些環保設計工具或根據一些綠色認證標準，可協助設計者更有系統及更全面地考慮各環保因素。
    - 應用環保設計工具(Ecodesign tools)
    - 獲取綠色認證/可生物降解標籤/堆肥標籤

## 第五節　表現評級

這個針對塑料袋業的綠色生產評估系統是一個行業通用的模式。當中，「0」級為最低級，亦表示表現最差劣；「5」級為最高級，表示已達到籌委會所認知的世界性最高水準。評核者在進行評核時會考慮到在收集數據時可能出現的誤差，如所得的數據介乎兩個級別之間，評核者會憑其本身專業的判斷決定最適合的評級。

如需詳細的評估和等級評定的方法，
請參考手冊的“塑膠袋製造業的綠色生產評價計劃”

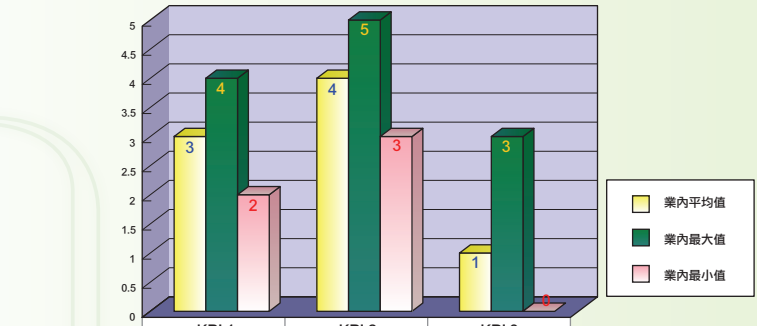
# 第五章

# 本地同業的綠色評估典範借鑑數據分析

# 第五章

# 本地同業的綠色評估典範借鑑數據分析

## 第一節　類別 1 - 能源管理




| | KPI 1 | KPI 2 | KPI 3 |
|---|---|---|---|
| 業內平均值 | 3 | 4 | 1 |
| 業內最大值 | 4 | 5 | 3 |
| 業內最小值 | 2 | 3 | 0 |

### KPI - 1 關鍵工藝能源消耗（kWh / kg）

***在塑料袋生產過程中，最主要的能源消耗是薄膜擠壓。這指標將比較在進行塑料薄膜擠壓時，能源使用是否有效。***

評估過程中，結果發現沒有公司在關鍵的加工設備如擠出機上安裝獨立功率計。而且，他們並沒有為每台擠出機的生產量作出全面性紀錄。因此在分析的時候，需作出某些估計和假設。

行業的KPI平均等級是3，這表明能源消耗的關鍵過程中還有地方需要改善。業界應更加注意擠出吹塑過程的能源效率：

- 選擇正確的擠出機
- 有效率地使用擠出機
- 按實際需求來配合生產
- 按實際需求來配置大小合適的電動馬達
- 測量能源表現
- 改良維修方法等等

## KPI - 2 工場能源消耗（kWh / kg）

***除了塑料薄膜擠出機外，塑料薄膜生產工場裡還有其他輔助設備，如燈管、通風系統等亦會使用能源，這些都不應被忽視的。***

行業的平均等級為4，這表明有些公司已嘗試找一些方法來節省工場的能源消耗，但仍可採用進一步的改善措施或高能源效率的設備。

由於大部分的工廠已建造了10年以上，節能設施或有關功能可能沒有被納入建築設計內。但是多數工廠都會安裝一些簡單的節能設備來取代前期較損耗能源的輔助設施，以減少能源消耗。如水冷式空調通風系統、生態空調、T8型號熒光工業照明燈等。而且他們亦取締了容量過大的輔助設備以減少能源消耗。

公司應該建立一套全面性的計劃來安裝各種節能裝置。隨著能源成本越來越高，這種設備將更具成本效益。他們應該評估安裝某些設備的可行性，例如：太陽能光伏板 /　系統的發電方式、熱回收系統、水回收系統等，以一切可能的方法來節省資源。

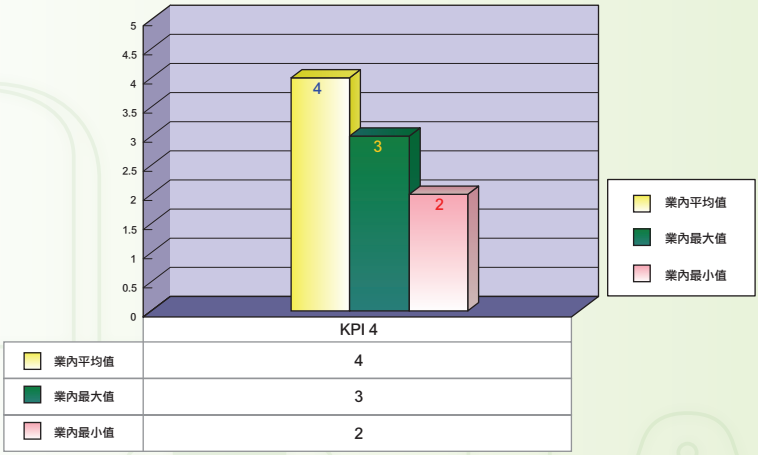
## KPI- 3 辦公室能源消耗 (kWh/$m^2$/annum)

***雖然辦公室一般的能源消耗相對地較生產工場少，但每個人如能從小處著手，亦有助節約更多的能源及成本。***

評估過程中，我們發現沒有公司於辦公室內安裝獨立的功率計，因此沒有作定期記錄分析。在分析的時候，需作出某些估計和假設。

業界的KPI-3平均等級為1，這表明業界在這個方面尚有很多地方有待改善。儘管大多數公司都建立了一套指標給工作人員遵守，但應該採取更進一步的監測措施和定期記錄有關能源消耗，從而加以改善。為了節約能源，在更換舊設備如電腦、打印機、空調等的時候，建議使用有能源標籤的電器。照明控制系統方面，盡可能利用自然光。有需要時，建議使用節能T5 / T8熒光燈。亦建議使用自動照明控制系統/設備和分區照明控制系統。

## 第二節　類別 2 - 噪音污染



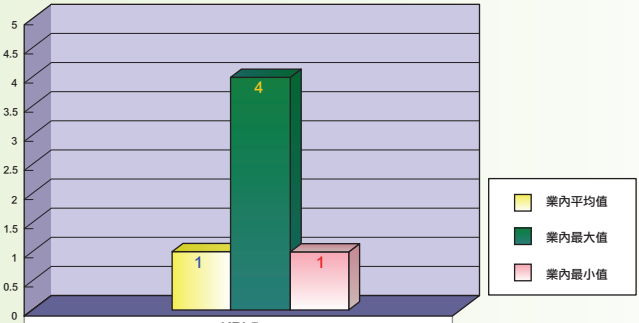

| | KPI 4 |
|---|---|
| 業內平均值 | 4 |
| 業內最大值 | 3 |
| 業內最小值 | 2 |

### KPI - 4 噪音污染（dB）

***塑料袋生產商一周7天，每天24小時運作。因此，工廠發出的噪音可能會騷擾人類和動物之間的活動或平衡。***

評估過程中，結果發現噪音污染的問題一般。基本上，塑料袋生產廠所發出的噪音是不會影響廠房外的其他地區。測量出的噪音水平基本上是背景的噪音。例如：如果工廠位於公路旁，噪音的水平測量將會高些，而如果該工廠座落於農村地區，噪音水平將會較低。

# 第三節　類別 3 - 管理系統




| | KPI 5 |
|---|---|
| 業內平均值 | 1 |
| 業內最大值 | 4 |
| 業內最小值 | 1 |

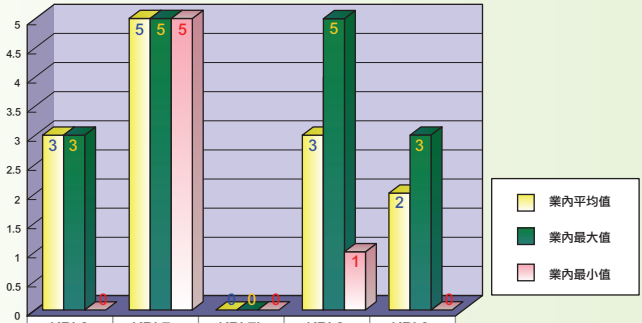
## KPI - 5 環境管理系統標準

***全面性的環境管理系統可以幫助公司保持良好的環境表現指標。***

行業的KPI平均等級是1，從資料顯示，相對其他行業，他們對實施環保製造管理(如較廣泛應用於ISO14000)的做法並不普遍。大多數企業只建立一些簡單的環保採購政策。所以，他們應該重新檢討採購政策以制定更具體的措施，並制定更全面的供應商評估計劃。應運行一個更具系統的持續改善計劃，以設立一個適當的渠道，使可行的改進建議得以實行，並獲得成功。

由於ISO 14001是衡量公司環境管理水平的國際公認指標，所以公司應該把它視為一種有用的指導環保生產工具，不應看成為一個負擔。並應把它視為一項殊榮及好好利用它去改善公司成為一個綠色的生產者。

# 第四節　類別 4 - 產品設計




| | KPI 6 | KPI 7a | KPI 7b | KPI 8 | KPI 9 |
|---|---|---|---|---|---|
| 業內平均值 | 3 | 5 | 0 | 3 | 2 |
| 業內最大值 | 3 | 5 | 0 | 5 | 2 |
| 業內最小值 | 0 | 5 | 0 | 1 | 0 |

## KPI - 6 塑料

塑料是塑料袋的主要原料。生產商應考慮以下內容來選擇樹脂：

— 符合RoHS指令或同等要求

— 可再生（如PHA, PLA）

— 可降解（生物 / 光 / 水 / 氧降解）

這是一個市場主導的世界，製造商在很大程度上是根據需求而製造產品的。業內的KPI平均等級是3，這表明環保塑料在市場上的需求仍然不算龐大，製造商也沒有很大的動機應用環保塑料。

現時，大多數企業均認為，達到RoHS標準是一個基本的環保要求。但是，大多數企業只了解RoHS的要求，但他們的認證證書的收集和保存系統仍然需要改進。由於成本較高，可再生原料例如PHA和PLA在市場都並不流行。對於其極低的應用率並不感意外。然而，可降解塑料的市場正在增長，企業應把握此機會，生產更多可降解的產品，從而達到環保成效。

## KPI - 7a 印刷油墨及溶劑 — RoHS 認證

***印刷油墨及溶劑也是塑料袋生產中的重要污染源。所以，生產商應考慮選擇符合RoHS認証或同等認受的印刷油墨和溶劑。***

業內的KPI平均等級為5，這表示所有被評估的公司均使用符合RoHS認證的印刷油墨和溶劑。這點也顯示出，符合RoHS認證要求的印刷油墨和溶劑已是行業間公認的。最大的原因是，符合RoHS的印刷油墨已成為多數出口國一個基本的安全規定和環保要求。因此，大多數企業已了解RoHS的要求，但認證證書的收集和保存系統仍然需要改進。

## KPI -7b 印刷油墨及溶劑 — 揮發性有機物(VOC)含量

***印刷油墨及溶劑內的有害揮發性有機化合物（VOC）是塑料袋生產中的重要污染源。生產商選擇印刷油墨和溶劑時，應認真考慮這一點。***

業內的KPI平均等級為0，這表示生產商甚少關注印刷油墨及溶劑內的VOC含量，而且，他們沒有動機去促使他們使用低VOC含量的印刷油墨和溶劑。

許多國家已確定揮發性有機化合物是空氣的污染源，他們已制定了法規限制塗料和油墨所揮發出的揮發性有機化合物含量。據報導，在不久的將來，內地也會建立類似的法規。因此，我們建議製造商放棄使用溶劑型油墨，反之採用低揮發性有機化合物含量的油墨，如以水、油及大豆為基礎的印刷油墨等。否則，他們應考慮安裝揮發性有機物抽氣系統，以避免揮發性有機化合物排放到空氣中。他們亦可使用揮發性有機化合物回收系統將揮發出來的有機化合物回收。

## KPI -8 塑料減用

***當設計一個環保膠袋時，如能套入3R概念：減少 / 重用 / 再造，將有助減少物料的使用。這指標將評估公司在設定塑料配方時有否考慮能減用塑料的方法。以下為最主要的原塑料減用方法:***

— 應用循環再造塑料

— 應用碳酸鈣作為填充劑

— 應用茂金屬催化劑以增加膠袋的強度

業內的KPI平均等級為3，這表示有公司已經努力尋找其他途徑，以減少使用原材料。一方面，這樣做較為環保，另一方面，亦可節省成本。

所有公司均全面回收廢料和將廢料再造以投入生產。可是，可靠的再生樹脂供應有限，因而限制了其使用。在考慮不同的產品規格和應用時，各公司亦有嘗試採用碳酸鈣和茂金屬催化劑，以減少材料使用量。

## KPI - 9 設計方法 (ODM 及 OBM 產品)

***在設計環保塑料袋時，生產商應同時考慮應用一些環保設計工具及考慮現有的綠色標籤及認證所需的標準。***

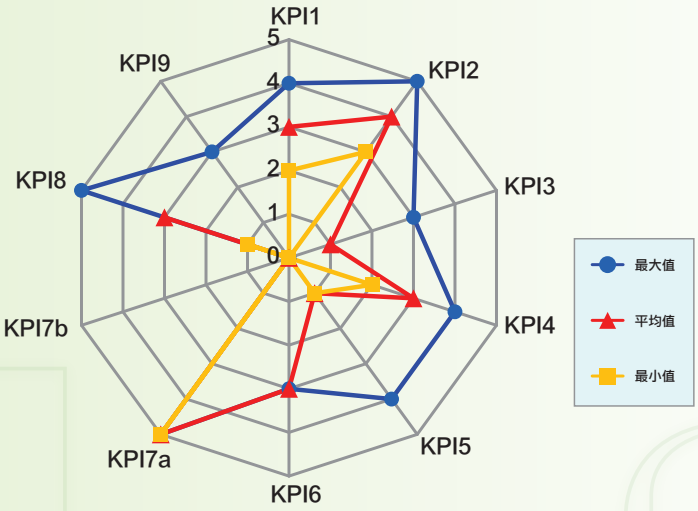
業內的KPI平均等級為2，這表示行業的環保設計和環保產品對業界尚是一個新概念。

在大多數情況下，塑料袋生產商只著重設定塑料袋的配方，而非塑料袋的外觀。而且，他們只靠經驗設計，而沒有將設計上的邏輯和知識有系統地記錄下來，這導致一些環保因素或考量，如對環保材料的應用、減輕重量的設計、重用的設計、循環再用的設計等未納入考慮中。當我們論及環保設計工具的時候 ，所涉及的層面非常廣。相對於其他行業，塑料袋產品設計和製造相對簡單，因此，我們建議公司為其產品開發團隊制訂一套全面性的環保設計製作清單，作一個好開始。

現時，塑料袋產品的綠色標籤和認證仍然不普遍，難怪使用率偏低。然而，綠色標籤及認證制度中的一系列標準和指引絕對是值得學習的，而且更可在編製環保設計核對清單有啟發作用。

# 第五節　總結

## 塑料袋製造業
## 主要表現指標的總結及分析




- KPI-1　關鍵工藝能源消耗 (kWh / kg)
- KPI-2　工場能源消耗 (kWh / kg)
- KPI-3　辦公室能源消耗 (kWh/$m^2$/annum)
- KPI-4　噪音水平 (dB)
- KPI-5　環境管理系統標準
- KPI-6　塑料
- KPI-7a 印刷油墨及溶劑 - RoHS 認證
- KPI-7b 印刷油墨及溶劑 - 揮發性有機物（VOC）含量
- KPI-8　塑料減用
- KPI-9　設計方法 (ODM 及 OBM產品)

# 第六章

# 最佳運作典範(本地及海外)

# 第六章

# 最佳運作典範 (本地及海外)

在為試點塑料袋製造公司進行“綠色生產評估”的過程中，我們在不同公司收集了一些最佳或良好的運作模式。另外，透過參考一些著名的塑料袋生產商（本地及海外）的運作模式，我們整合並編寫了一系列最佳運作模式推薦給本地的塑料袋製造商作參考。

## 第一節　類別 1 - 能源管理

### ■ 高效率的熱塑性塑料擠出

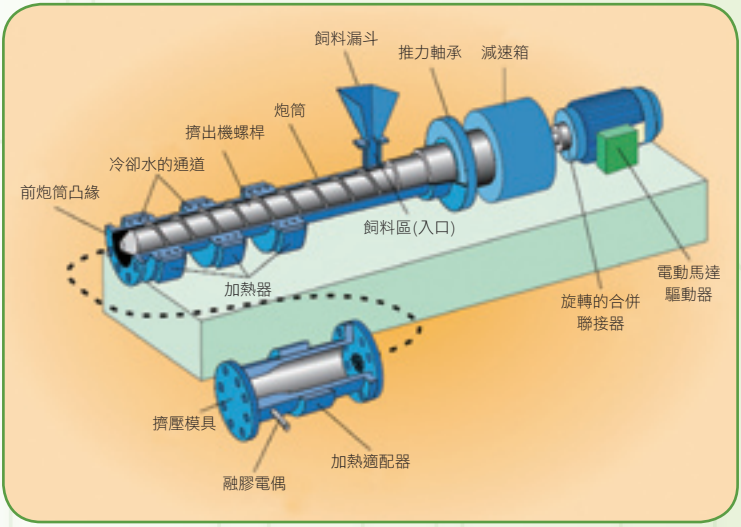



*圖6.1典型的擠出機的結構*

生產塑料袋時，薄膜擠出被認為是一項較損耗能源的過程。因此，生產商應改善此點，從而達到最合乎經濟效益。圖6.1顯示了擠出機的基本結構。組成擠出機的主要部分是：

— 電動變速驅動器，通常是直流電動馬達所驅動;

— 變速箱連同一個動力保護裝置;

— 炮筒及螺桿系統;

— 將融化的聚合物成型模具系統

擠出機的中央是一支裝在炮筒內的旋轉螺杆。聚合物會以粉末或顆粒狀經由料斗進入炮筒後，並沿著螺桿的轉動流到模頭。聚合物會被裝配在炮筒外圍和模頭外面，經過加熱的電熱圈以及螺杆的機械動作融化（或軟化），同時並提供壓力迫使聚合物通過模頭。

擠出機中，最為常見的螺桿直徑範圍是30至90毫米，最大輸出功率為30-600公斤/小時。驅動器和加熱器輔助的功率範圍是15-60千瓦。當兩種聚合物同時共擠時，可使用螺杆小至15毫米的小型擠出機。螺桿的長度直徑比徑（L/D）通常是25:1或更高，但過高的比例可能會造成磨損和振動等問題，因為螺桿只在尾端以軸承支撐。

以下是一些擠出機的節能參考。雖然大多數建議看似一般常識，能馬上推行而不須投放大量資金，但為了更有效地使用能源，我們需要制定明確的指標量度能源效益，找出耗能的源頭，加以優化機器的性能，以提高生產的成本效益。

### ◆ 選擇合適的擠出機

擠出機的螺桿和炮筒主要是提供一個適當壓力把聚合物在正確的物理狀態下輸送到模頭。首先，聚合物須經過加熱，再加上機械剪切加熱，確保聚合物流到模頭。外部加熱（炮筒加熱圈）和內部熱能（旋轉螺杆的剪切力）之間需要一個重要的平衡。當大部分的熱能由旋轉螺杆的剪切力產生時，整個加熱過程是比較有效的。另外，有兩個關鍵因素會影響這個平衡，包括螺杆／炮筒的直徑和螺桿設計。

*螺桿 / 炮筒直徑*

**請勿因貪方便而胡亂選擇機械。**

**請勿使用大直徑螺杆的擠出機去生產橫切面較小的產品。**

當擠出機螺桿轉速接近其設定轉速的時候，即相當於炮筒內聚合物的線性速度時，其效率會較高。而聚合物的線性速度（$S_B$）則與擠出的線性速度（$S_E$）有關：

$$(S_B) \approx (S_E) * A_E/A_B$$

$A_E$ = 擠壓剖面的橫切面面積

$A_B$ = 擠出機的螺杆和炮筒之間的凹處的平均橫切面面積

聚合物的類型、產品的外觀設計和下游輔助設備的容量均為$S_E$ 值設下最高上限。其中可能是因為下游的處理設備無法應付更高的流速，亦可能因有限的冷卻能力，使產品過熱變軟而變形，以致降低其質量。

上述的方程式中，$S_E$ 的上限同時限制了$S_B$ 的上限，導致當$A_E$ / $A_B$ 的數值較小的時候， $S_B$ 數值會較小。換句話，螺桿/炮筒直徑較擠出的型材截面為大時，$S_B$ 的值相對為低。偏低的$S_B$ 值代表轉速低和浪費能源。

*檢查：*

— 機器中的螺杆直徑是否過大？

— 螺杆設計方面，是否適用於該種聚合物和產品？

◆ **有效地操作擠出機**

螺杆的旋轉及直線運動與它的螺距有關，而螺距與螺桿的外形設計和螺紋之間的空隙會影響對聚合物產生的剪切力。因此，螺桿設計不能獨立地考慮，如擠出機的運作受聚合物的性能、產品橫切面及使用的模具影響。因為擠出機可以在不同

材料和產品設計的情況下擠出不同的產品，但它的效率也會因運作情況差於設計運作環境而下降。

*檢查：*

— 機器速度方面 - 擠出機是否高效率地運行（通常是最大設計速度）？

— 機器運行方面 - 炮筒的加熱器和冷卻風扇在機械運行時是否沒有關上？

— 溫度方面 - 聚合物所需的溫度是多少？

— 電機驅動器 - 電動機是否過大？

— 磨損方面 - 能源使用是否受到監管（以檢查退化跡象），並採取行動？

◆ **供應需符合實際需求**

*檢查：*

— 冷卻水 - 是否持續浪費於閒置的機器上？

— 冷卻水 - 過程中是否符合加工工序的最高溫度及最低質量要求？

— 冷卻水 - 是否有效地處理，冷凍及使用？

— 壓縮空氣 - 是否提供給一些閒置的機器上？

— 壓縮空氣 - 是否用最低的壓力及質量供應到所需的工序上？

— 真空度 - 加工時，是否達到加工的真空度最低要求？

— 真空度 - 是否有效地生產及分配使用？

— 屋宇裝備 - 機器在無人或閒置時，照明和通風是否仍然開啟著？

◆ **電動機的尺寸需符合實際工作需求**

雖然使用新型、較細少或從零部件改裝的電動機來更換以往過大的電動機似乎不一定符合成本效益，但從後備配件中重新裝配合適的馬達卻真的可以減少能源消耗。因此，最理想的就是清楚知道每項設備所需的電動機大小，以確保有需要時作替代，例如：如果電動機燒壞，可以更換合適的馬達。

### ◆ 維持輔助和公用設備

*檢查：*

— 機械的磨損程度

— 絕緣體的品質

— 分配系統的限制和洩漏

— 電動機和加熱器的電器性能有沒有老化

— 傳感器和控制系統的調正

### ◆ 計量能源成效

### ◆ 快速參考清單

## ■ 通過能源改善以減少維修

通過改善妥當的維修計劃來減少能源消耗的做法，包含9個不同領域，當中效率低的保養維修工作只會增加能源消耗。以下的討論，以評估和找出會增加能源消耗的維修工作作開始。

摩擦絕對是維修部最大的敵人。因摩擦而產生的熱度會使系統磨損，這樣會直接影響能源損耗的水平；機器上的摩擦越多，操作機器所需的能源也越多。而維修部的主要責任是確保加熱、冷卻和動能生產系統（壓縮空氣和蒸汽）的運作水平不低於原來的設計的最低水平，並確保有關的低效能和能源損耗直接監控。在這種情況下，維持保養工作會繼續成能源效益的直接因素，更會被看作為一項有效減少能源浪費的重要任務。

### ◆ 潤滑

適當的時候使用適當的潤滑劑可有效地減少能源消耗，而節省的金額將取決於摩擦、磨損和潤滑劑失效所造成的損失。而一些成功的例子已經證明有效的潤滑可節約能源超過20%。

除了節省能源以外，有效的潤滑可減少停機時間、減少經常轉用潤滑油、並增加設備壽命等。

**快速提示：**

- ✔ 執行一個潤滑效能的評估，尋找有效的潤滑措施和潛在的改善機遇。最好以第三方顧問的研究經驗提供一個公正的客觀評估。
- ✔ 確定所有需要潤滑的設備和要求。可參考潤滑手冊或潤滑劑潤滑製造商，或聘請顧問。
- ✔ 收集潤滑油的要求。
- ✔ 如有疑問，請參考設備製造商的指南，正確使用潤滑劑或潤滑油。
- ✔ 制定明確政策，說明如何採購和使用潤滑油，以及儲存潤滑油的方法。
- ✔ 根據實際使用情況而更換潤滑油，而不是依賴通用設備製造商的建議。分析潤滑油，以確定更換密度。
- ✔ 研究使用優質和人工合成的潤滑油，以符合最佳的成本效益。
- ✔ 在使用潤滑油的前後執行能源使用分析，以計算出可節省的成本。

### ◆ 壓縮空氣系統

在一個典型的壓縮空氣系統中，有25%的能源損耗是因為系統效率低下而浪費。系統不合適的設計和維護，都可反映在以下幾點：

— 壓縮機性能降低

— 壓縮空氣洩漏

— 分配系統降壓

如同所有的設備，壓縮空氣系統需要精心設計和維護，以便有效地運行。壓縮機需與一個工廠的運作需求以及工廠週圍環境配合。不論系統如何設計，通過使用有效的維修方法，現時的能源消耗可以大大減少超過25%。

**快速提示：**

- ✔ 執行空氣壓力的審計研究，以尋找出節約能源的機會。
- ✔ 把定期氣體泄漏檢查納入為預防 / 預算維修計劃的一部份。
- ✔ 如果情況許可，使用人造壓縮機潤滑油。這將降低能源消耗，並可延長潤滑油的更換時間達5倍。
- ✔ 可行情況下，應使用電動馬達而非氣動馬達，使用電動控制而非氣動控制，使用電動工具而不是氣動工具。壓縮氣動設備的用電量比電動設備多4倍。
- ✔ 把壓縮空氣過濾器的定期檢查和更換納入為預防維修計劃的一部份。

### ◆ 電器連接

假若電器連接的大小合適和適當地上緊，它能確保一個良好的接駁和正常的運作，而且不需要太多的維修。但是，若忽視這兩個領域，可構成消防安全危機，這樣，更可能導致不必要的能源開支，因為一個簡單的鬆散連接可以浪費數以千計的利潤。

**快速提示：**

- ✔ 利用紅外線熱能探測儀去量度電源接駁可以大大減少檢查和維修生產設備的時間。
- ✔ 要符合製造商所制定的電器接合規格。
- ✔ 利用肉眼檢示電器絕緣體有沒有受熱產生裂紋和磨損，如有懷疑，應立即替換。
- ✔ 檢查電源接頭是否鬆動或有機械磨損。如有損壞，應立即維修或替換部件。
- ✔ 檢查保險絲和刀制是否完全接觸。
- ✔ 檢查繼電器是否來回不斷跳動（繼電器在正常的情況下會完全接觸狀態，如不成功，一般都是因污垢引起的。）
- ✔ 如發現不尋常的聲音和氣味，應立即檢查和報告。

## ◆ 機械驅動系統

機械驅動的傳送系統透過一些機械裝置如聯軸器、齒輪、皮帶、鏈條和凸輪、關節、離合器、制動器等將電動裝置的電能傳送到驅動裝置。這個機械驅動的傳送系統用以改變馬達軸承到驅動裝置間的扭矩速度和位置。

激光校對設備製造商聲稱改善軸承連接的旋轉設備的對中較直可最多節省11%的能源消耗，同時延長了機械聯軸器、齒輪、軸承等壽命達8倍。

**快速提示：**

- ✔ 確保皮帶和鏈條的鬆緊度任何時候都保持正常。
- ✔ 研究自動調校鬆緊度的裝置（配有彈簧的惰輪）。
- ✔ 製造“go, no-go”的測量錶，可快速檢查拉力裝置。（“go, no-go”是一個加工的儀器，把它放在一個參考點就可知道這個位置的拉力是否在設定的範圍）。
- ✔ 保證制動器不會鬆開。
- ✔ 檢查變速箱中的潤滑油粘度是否適中。機械配件不對中會導致磨損，這種磨損可透過分析潤滑油得知。
- ✔ 當設備已正確對齊，以油墨寫上標記以方便對位。如有移動或錯位，標記就會移位，表示對中有問題。

## ◆ 餘熱和冷卻回收

一般的維修保養計劃都不包括熱回收和冷卻系統。但是，越來越多公司要求維修部門負責能源預算。因此維修部門必須考慮所有節省能源的機遇。其中一個好方法是引進熱回收和冷卻系統。

熱回收方面，我們必須獨立計算所得的節約效益。計算回收的熱量及所節省的成本是頗容易的。

在一個封閉式油冷螺桿式壓縮機中，熱能回收可高達94%的總電量。壓縮空氣系統製造商提供熱交換器來生產熱水，這些熱交換器提供溫度範圍在130°F至160°F的熱水。由於大多數廠房或設施均利用此壓縮空氣系統，所以現時有許多公司已擁有熱回收節能的先決條件。

**快速提示：**

- ✔ 使用紅外線檢測器檢查熱交換器的效率和操作是否正常。
- ✔ 使用紅外線熱能影像探測來檢查絕緣狀況及耐火老化情況。
- ✔ 一旦確認可以將熱量回收，應立即執行有關的工程研究和節約分析，以最佳的方法回收熱量，從而得到最佳的投資回報率。在這一領域，可查詢當地的公司和顧問。

### ◆ 工場管理

當優化後的工場管理正式執行以後，可同時獲得多方面的節省。

| 良好的工場管理可減少: | 從以下各方面達致節約: |
|---|---|
| 導致磨損的污染物 | 增加部件的壽命，延長潤滑油的壽命，減少能源損失 |
| 產品污染 | 更佳的控制質量，減少因重做而引起的能源和資源的成本 |
| 部件失零 | 鑑定隱患 |
| 能源損耗 | 改善接觸面，減少熱量，提高效率冷卻，減少因過濾介質導致的壓力下降 |

**快速提示：**

- ✔ 清潔設備應視為定期維修的一部分。
- ✔ 只要有可能，空氣過濾設施應安裝在設備以外的地方，以便可以容易地看到機械的狀況，從而有需要時而作出改變。

## ◆ 有計劃的維修習慣

維修計劃（P.M.）是行業眾所周知的縮寫，但它的意思可以指許多不同的事情。P.M. 的定義可指示為積極的維修計劃而不是被動的“救火式”方法。福特汽車公司於80年代進行了有關研究，發現P.M.所佔的費用是被動的的維修方案的三分之一。

差劣的維修計劃可能會增加不必要的能源需求。若能把維修計劃規範化，可消除一些因能源需求增加的不必要成本和免除過度維修。

**快速提示：**

- ✔ 檢查現有的維修計劃指引是否含糊。
- ✔ 任務的定義必須簡潔、描述清晰及容相關。
- ✔ 儘可能，為每個步驟註上編號，加上“如果”和“然後”使所有步驟更容易明白。
- ✔ 按照實際規格，以維持計劃任務。
- ✔ 定期制定一個反饋報告。例如:使用定期維修計劃後機械的表現如何？實施定期維修計劃後能源消耗情況。

## ◆ 工業照明

照明是任何工作場所的一個重要部分，因為照明水平的高低與工作表現和工作場所的安全息息相關。選取照明系統是取決於工作區所執行的工種和活動。目前，在工業工作場所範圍內，有3種照明系統被廣泛使用：白熾燈、熒光燈和高強度能量燈（鈉、金屬鹵化物、汞蒸氣）。

如果考慮到照明系統能源效率，熒光燈的效率比白熾燈高3倍以上，而高強度能量燈的效率又比熒光燈高2.5倍。除了關注光源外，熒光燈裝置可安裝一面如鏡子般的反射板來反射角度，以更有效地增加光線折射。燈光較暗的地方，反射板可以

增加光度15%; 在燈光過亮的地方，可從固定裝置中移除燈具和鎮流器，從而可減少光度25%，更加可減少能源消耗達50%。使用反射器還可以減少燈和鎮流器的使用。

**快速提示：**

- ✔ 定期清潔反射板和燈。
- ✔ 執行燈光管理，以確定實際所需的照明系統和一些潛在的能源節約機遇 。
- ✔ 以小巧型熒光燈取代白熾燈，因為可減少80%的能源消耗和耐用4倍，一年之就可審會省會回成本。

*(Source: "Energy Reduction Through Improved Maintenance Practices; Kenneth E. Bannister")*

## ■ 建築物及辦公室的能源效益及節約

- ◆ 可持續的資源
- ◆ 空間規劃
- ◆ 建材
- ◆ 建築物坐向
- ◆ 外部遮光裝置
- ◆ 建築的遮掩範圍
- ◆ 電力裝置
- ◆ 照明裝置
- ◆ 低功率辦公設備
- ◆ 空調安裝
- ◆ 電梯的安裝和自動扶手電梯安裝
- ◆ 管道和排水裝置

## 第二節　類別 2 - 噪音污染

由於塑料袋生產屬於輕工業，工廠所產生的噪音是可以省略的，它們基本上不會影響到工廠邊界以外的地區。

可是，一些工場如擠壓機房、印刷機房的噪音水平都是很高的，因此我們建議所有工作人員應強制性戴上耳筒，以保護自己聽覺。

## 第三節　類別 3 - 管理系統

- **環保採購政策**
- **環境改善計劃**
- **ISO 14001標準**
- **其他環境管理系統，例如，ISO 14062，QC080000等**

## 第四節　類別 4 - 產品設計

- **環保塑料**
  - 符合RoHS認証或同等認受
  - 可再生塑料
  - 可生物降解塑料
- **環保印刷油墨和溶劑**
  - 符合RoHS認証或同等認受
  - 低VOC的印刷油墨和溶劑
    - 以水為基材的印刷油墨的材料
    - 以油為基材的印刷油墨的材料
    - 以大豆為基材的印刷油墨的材料
  - 去除/回收VOC的系統

## 塑料減用

- 使用循環再造塑料
- 使用碳酸鈣（$CaCO_3$）作為填充物
- 使用茂金屬催化劑以改善塑料袋的強度

## 設計方法（ODM及OBM產品）

- 應用環保設計工具
  - 環境沖擊評估表
  - “Philips Fast Five ”清單
  - 生命週期分析（LCA）
  - 分析清單
  - 環保設計清單
- 了解本地及海外的環保認證/綠色標誌/可生物降解和可堆肥產品指標
  - 可降解/可堆肥的公認標準（如ASTM D6400/EN13432 / DIN V 54900）
  - THE COMPOSTABILITY MARK OF EUROPEAN BIOPLASTICS AND DIN CERTCO

    *(Source:http://www.dincertco.de/en/about_us/our_marks_of_conformity/the_compostability_mark_of_european_bioplastics_and_din_certco.html)*
  - 環境保護署-可降解容器及袋的登記計劃

    *(Source:http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/guide_intro.html)*
  - 香港環保標籤計劃-可降解非食物或飲料容器及袋(GL-005-006)的產品環保標準

    *(Source: http://www.greencouncil.org/eng/doc/GL005006.PDF)*
  - 北美（Environmental Choice（Ecologo）/德國（Blue Angel）/美國（Green Seal）/日本（Eco Mark） /新西蘭（Environmental Choice New Zealand）

    *(Source: http://www.gen.gr.jp/product_link.html)*
  - 其他地方的綠色標籤計劃

**Hong Kong Plastic Bags Manufacturers' Association**
**香港塑料袋業廠商會**

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