

# **Asia-Pacific Economic Cooperation**

## **Eco-Efficiency in Small and Medium Enterprises – Machinery and Electrical Equipment Industry**

**APEC Small and Medium Enterprises Working Group**

**1998**

## **FOREWORD**

This Manual has been prepared as a guide for the introduction of eco-efficiency practices in the MACHINERY AND ELECTRICAL EQUIPMENT INDUSTRY. It is specifically aimed at small to medium sized enterprises, and provides practical guidance for identifying and evaluating opportunities for eco-efficiency in the workplace.

This manual will help you to identify opportunities for reducing costs and improving environmental performance at your company. This can be achieved through reductions in raw materials and the costs of waste management; creation of marketable by-products, new markets and increased market shares; energy savings, reduced pollution and consent charges, reduced fees and penalties; and worker health and safety.

The Manual is one of a series covering a range of industrial sectors, and has been developed following research conducted under the funding and direction of the Asia Pacific Economic Co-operation (APEC). Other sectors covered in the series include:

- the chemicals and plastics industry;
- the textile industry;
- the steel and metal products industry;
- the paper and printing industry;
- the leather products industry;
- the vehicle parts and assembly industry; and
- the food and beverage industry.

### **THIS MANUAL CONTAINS THE FOLLOWING SECTIONS:**

<b>1. ECO-EFFICIENCY - MAKING BUSINESS MORE PROFITABLE</b>	<b>P.1</b>
<i>Explains the background to the eco-efficiency concept and the benefits to small and medium enterprises.</i>	
<b>2. ASSESSING OPTIONS FOR ECO-EFFICIENCY IN THE WORKPLACE</b>	<b>P.4</b>
<i>Describes how to identify and evaluate opportunities for eco-efficiency and waste minimization.</i>	
<b>3. DEVELOPING PRACTICAL SOLUTIONS</b>	<b>P.12</b>
<i>Illustrates management and process changes in the machinery and electrical equipment industry which have been adopted around the world.</i>	

#### **4. MONITORING YOUR PROGRESS**

**P.18**

*Outlines the importance of measuring the benefits and maintaining the drive for improvement.*

# 1 ECO-EFFICIENCY – MAKING BUSINESS MORE PROFITABLE

## 1.1 OVERVIEW AND COST SAVINGS

What is Eco-Efficiency?

The concept of eco-efficiency parallels that of industrial efficiency - or *good business sense*. By reducing waste (here we refer to all types of waste, including time, energy, money and resources), industrial activities can move toward efficient and profitable operation. As a management practice, therefore, eco-efficiency *aims to do more with less*.

Eco-efficiency measures need not incur large financial investment into new technologies or processes, but can often be brought about simply through better housekeeping. In this context eco-efficiency includes *...any initiative or measure undertaken by an industry which results both in reduced environmental impact and increased efficiency and resulting cost savings for the company concerned. Typical examples of eco-measures are waste minimization, clean technology, and the reduced use of energy or materials per unit output. An eco-measure may also be management, process, technology, or production orientated, but will generally not include “end-of-pipe” treatment.*

Eco-Efficiency Saves Money

Cost savings may be immediate financial returns that appear directly on the balance sheet, such as material, energy and water savings. However additional savings may well arise in the future, perhaps from the reduced ‘clean-up’ required for contaminated land. The following shows some examples of eco-efficiency initiatives in the machinery and electrical equipment industry in Canada, Japan, and the United States and their associated savings.

Eco-Option	Financial Information
In Canada, a manufacturer of microwave devices eliminated the need for (1,1,1-trichloroethane) as a vapor degreasing solution.	Approximately \$9200 Cdn per year was saved.
In Canada, freon based flux was replaced with a VOC-free flux for the flux cleaning process in the manufacture of microwave devices.	The elimination of freon produced savings of \$6250 Cdn per year.
In Japan, housekeeping measures were adopted to reduce copying	Copy paper use was reduced by 86%, resulting in annual savings of

<b>Eco-Option</b>	<b>Financial Information</b>
paper.	65,000 yen.
In Japan, a manufacturer of electronic sensors replaced polystyrene padding with cardboard chips for packaging.	An estimated 750,000 yen was saved in materials and waste disposal costs annually, compared to an annual rental of 144,000 yen for the cardboard cutting machine.
In the US, a 12% reduction in water usage was achieved through the installation of flow meters.	The cost of the measure was US\$400 and the net savings were US\$920 per annum.

## ***1.2 WHY SHOULD YOU BE CONCERNED WITH ECO-EFFICIENCY***

### **Are You Operating Within the Law?**

As economies continue to expand and develop, the regulations adopted by governments to protect the environment will become more stringent and better enforced. Businesses have in the past addressed tougher regulations by using more and more 'end of pipe' technologies to reduce pollution. However, these technologies are costly, and often need upgrading to keep pace with the new regulations.

An alternative approach, adopted by more forward thinking companies, is to change their existing practices to eliminate or reduce the wastes they produce. This adoption of eco-efficiency minimizes the for end-of pipe technologies and hence directly reduces costs.

### **Are You Missing Key Opportunities?**

A good eco-efficiency program will identify and exploit the market opportunities associated with good environmental practice. Many firms have discovered new business opportunities as a result of their efforts to solve pollution problems (for example the sale of waste by-products as a raw material to other businesses) and the promotion of 'green' products. These opportunities, if properly pursued, can not only offset the costs of the program, but can lead to increased profits

Moreover, effective eco-efficiency programs can identify other opportunities for reducing production costs, meeting customer and supplier requirements, improving worker health and safety, enhancing the company's public image and preventing potential future liability problems.

How is Eco-Efficiency Linked to the ISO 14000 series?

The International Standards Organization (ISO) 14000 series of standards is the main vehicle

defining and supporting the application of environmental management systems (EMS). ISO 14001, the standard appropriate to most manufacturers, requires that an organization identify the *“environmental aspects of its activities, products or services that it can control and over which it can be expected to have an influence, in order to determine those which have or can have significant impacts on the environment.”*

ISO 14001 includes routine internal monitoring of environmental performance against defined targets for improvement. It is then important to note that the successful implementation of the ISO 14001 standards in many ways parallels or supports particular eco-efficiency objectives, for example to reduce raw material usage and waste production.

ISO 14001 is already required for many industrial operations in Western Europe and in North America. In addition, and with regard to international trade, overseas markets are increasingly making ISO 14001 a requirement of their suppliers, and interest is continuing to increase throughout Asia.

## **2 ASSESSING OPTIONS FOR ECO-EFFICIENCY IN THE WORKPLACE**

This section describes how to go about identifying and evaluating potential opportunities for improving eco-efficiency in your workplace. This process is in principle the same for all types of industry, and consists of four basic steps:

- Step 1 - preparing for the assessment;
- Step 2 - identifying opportunities for eco-efficiency;
- Step 3 - measuring the baseline; and
- Step 4 - evaluating the options.

The key elements of each of these steps are summarized in the following illustration.



## **2.1 STEP 1 - PREPARING FOR THE ASSESSMENT**

### **Commitment from Senior Management**

Like all important business decisions, eco-efficiency requires the full commitment and support of top management for its successful implementation. Before anything else, the management must first develop its strategy for the eco-efficiency assessment. The key factors to be defined by the strategy are the objectives (what management hopes to achieve), the timescale for the assessment, and the resources which will be required (both human and financial). Once these factors have been defined, they can be put forward as an *Action Plan*, which allocates responsibilities to each of the team members.

### **The Focus of the Assessment**

A key element of the *Action Plan* is to define the focus of the assessment, which must be made clear during this preparation stage. For example, the assessment may focus on the whole facility, or perhaps on the operations of just one unit. On the other hand, the assessment may just look at key issues of concern, such as:

- raw material losses;
- wastes that cause processing problems;
- wastes considered to be hazardous or for which regulations exist;
- wastes which are or will be costly to treat and dispose of; or
- high energy consumption.

In whichever case, it is important to use simple flow diagrams of the operations and processes which are being investigated to keep track of the assessment. As a first step, the following information should be collected and reviewed:

### ***ECO-EFFICIENCY ASSESSMENT DATA***

- the quantities and costs of raw materials, water and energy;
- the processes that consume high water volumes;
- the processes that generate high wastewater volumes;
- the sources and quantities of each type of waste;
- waste management costs (storage, collection and disposal);
- discharge points of wastewater; and



- points of air emission.

### Getting Started

The size of the assessment team will of course depend upon the scale and complexity of the processes to be investigated. A more complicated process may require at least 3 or 4 individuals including technical, production and accounts staff. Informing employees of the aims of the assessment will also help the process, encouraging their cooperation and increasing their employee awareness.

The assessment should be undertaken during normal working hours so that machine operators can be consulted, actual operations can be observed, and wastes quantified.

## 2.2 STEP 2 - IDENTIFYING OPPORTUNITIES

The following checklist gives a general approach to identifying options for improved eco-efficiency in facilities of all types. Invest a little time in walking around your facility and ask yourself the following questions.

### **Resource Use**

1. Are batch sizes maximized and batches sequenced to minimize unnecessary cleaning and equipment warm-up or cool-down?
2. Could high-pressure water cleaning replace chemical cleaning?
3. Can process chemicals or additives be replaced by less damaging substances or mechanical processes?
4. Can alternative processes produce the same results with fewer resources and less waste?
5. Would overflow alarms for any tanks and vessels produce cost savings?
6. Do your processes have adequate and accurate monitoring and gauging techniques? Are raw materials or additives used in excess?
7. Are you aware of any incidents of production line personnel using more of a particular chemical '*just in case*'.

### **Waste Management**

1. Are you aware of all wastes and can you characterize them in terms of composition and quantity?
2. Are waste materials properly segregated and separately stored for appropriate disposal and possible re-use?
3. Is hazardous waste mixed with non-hazardous waste? If so, are non-hazardous wastes treated by costly hazardous waste techniques?

4. Is packaging and product filler kept to a minimum? Are products combined or condensed to reduce packaging?
5. Are all drums and containers thoroughly emptied before cleaning or disposal?

### ***Material Purchasing and Storage***

1. Do you know the shelf life and ordering system for raw materials? Does this affect loss through ageing?
2. Do your suppliers accept the return of outdated supplies? Do they keep their packaging to a minimum?
3. Can materials in store be inspected visually to identify corrosion or leaks?
4. Can materials be contaminated by others in the store? Are containers damaged by forklift trucks, etc?

### ***Re-use and of Recycling***

1. Is there any potential for mutually beneficial activities with neighboring industries? Could you utilize their by-products as a material resource, or sell your by-products to others?
2. Could your waste be used as a source of energy, by yourself or others?
3. Could packaging received from your suppliers be returned and re-used?
4. Could the packaging you give to your customers be returned and re-used?

### ***Water Conservation***

1. Would high pressure nozzles on hoses save water in cleaning equipment and workspaces?
2. Could taps and faucets be fitted with automatic shut-offs or flow restricters?
3. Is fresh water discharged after a single use? Is there potential to recirculate used water (for example from cooling) for re-use for other purposes such as cleaning?

### ***Energy Conservation***

1. Are you familiar with your overall energy profile and quarterly energy consumption levels and costs?
2. Are staff aware of energy issues, eg turning off equipment and lighting if not in use?
3. Are boilers, lights and refrigeration units old and efficient? How long

- would energy efficient plant take to pay for itself in savings?
- 4. Could more efficient motors replace old and inefficient ones? Are compressed air systems leaky?
- 5. How much energy might be saved through the use of better timer and thermostatic controls?
- 6. Do you have adequate thermal insulation on heating or cooling lines?

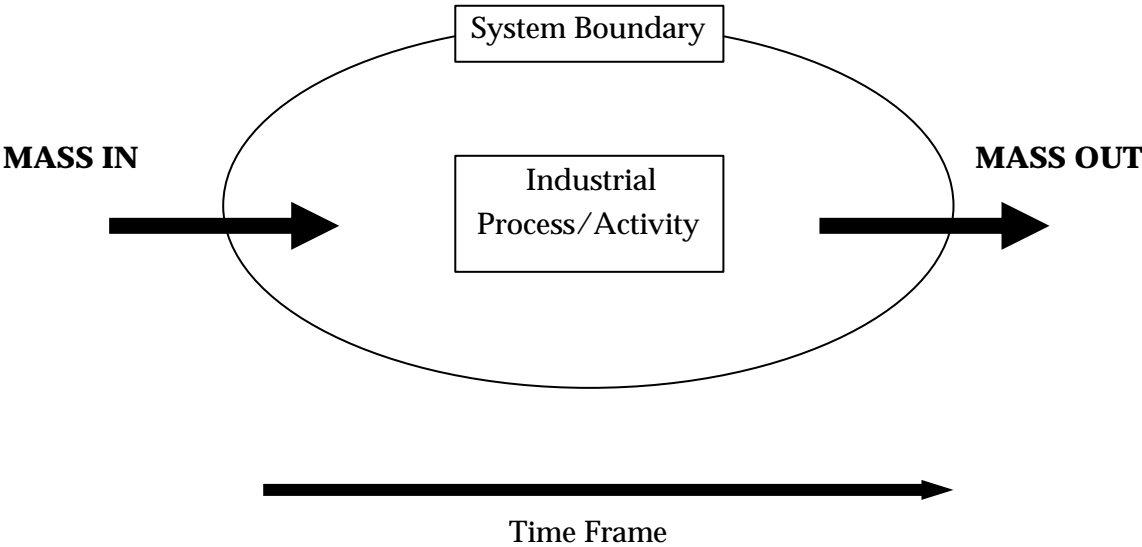
The answers to these questions will help identify where eco-efficiency can be improved, through changes in management or the processes and materials used.

**2.3 STEP 3 - MEASURING THE BASELINE**

Before eco-efficiency opportunities can be assessed, the current 'baseline' position needs to be quantified. Establishing the baseline situation will allow the benefits of eco-efficiency options (for example to reduce waste) to be quantified, both in terms of environmental improvement and cost savings.

**Undertaking a Mass Balance**

The simplest way to establish the baseline position is to undertake a *mass balance*. A mass balance measures the quantities of the inputs (raw materials, energy, water consumption, etc) going into a process, and the outputs (finished products, solid waste, effluent and air emissions, etc) which are produced as a result. In addition to measuring quantities, the mass balance is also applied to the associated costs (for raw materials, energy, water, and waste disposal, etc). The concept of the mass balance is illustrated below.



A mass balance can be undertaken to varying degrees of precision and depth. In evaluating eco-efficiency opportunities for small and

medium sized companies, it is prudent to limit the detail of the initial studies of the processes under investigation. Further detail can be added when the most promising areas for savings have been identified. The secret to a good mass balance, however, lies in its systematic and methodological approach.

#### Measuring Inputs and Outputs

The quantification of the inputs to a process includes two approaches:

- analyze purchasing records for materials and utility bills for energy and water to determine overall quantities involved; and
- measure actual quantities entering the process by counting, weighing or metering.

The output side of the mass balance consists of the same two principles:

- analyze waste disposal records for liquid and solid wastes, effluents, and production records for end products and by-products; and
- measure quantities leaving the process by counting, weighing or metering.

The most common area in which mistakes are made with a mass balance lies within the timescale over the analysis is undertaken. Particular care is needed in choosing an appropriate time period, and this is dictated by whether a continuous or batch process is being considered. For continuous processes, the times of any starts and stops must be accurately recorded. For batch processes, several batches should be measured (perhaps over the period of a week) to give a representative analysis.

#### Balancing the Inputs and Outputs

In an ideal mass balance, the quantity of materials going into a process equals that which comes out. However to reach such a level of detail is seldom feasible under limited timescales, apart from for very simple processes. Despite this, the mass balance approach still provides the basis for a better understanding of the production process. This in itself is the key to identifying areas of unnecessary wastage and where production processes and their management can improve with real cost benefits.

### **2.4 STEP 4 - EVALUATING THE OPTIONS**

If undertaken systematically, the first two steps of the assessment will

reveal a range of areas in which eco-efficiency can be improved, through both better management and process technology. In order to select the most appropriate option for your business, it is also important to take a systematic approach to their evaluation. Three factors need to be taken into account:

- the environmental performance of the option;
- the nature of the option and its implementation potential; and
- the cost of the option and its payback period.

Such an evaluation will of course include subjective considerations. The following technique, however, can be used to apply a score to each factor.

Environmental Performance
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Assessing the environmental performance can be complicated, particularly where different types of environmental effects have to be compared. As a starting point, it may be most practical to consider reductions in waste and the use of toxic substances as below:

- Reduction at source (raw materials, toxins, and energy) - 5 points.
- Resource recovery and in-process - 4 points.
- End-of-pipe recycling - 3 points.
- In-process treatment - 2 points.
- End-of-pipe treatment - 1 point.

Implementation Potential
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More than one eco-efficiency option may address the same problem (such as excess water use), however their implementation may involve different levels of complexity. For example, one measure may require substantial changes to existing plant and therefore result in unacceptable delays, where the other (perhaps more costly) option may provide an instant solution. Implementation potential can also be assessed using a scoring system:

- Highly likely - 4 points.
- Medium probability - 3 points.
- Low probability - 2 points.
- Highly unlikely but still worth considering - 1 point.

Cost of the option and payback
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Certain eco-efficiency options are high in capital cost and may seem unattractive. However, the savings which arise from the

option must also be taken into account when assessing its cost. Calculating the simple payback period is one useful tool for assessing the cost benefit. The simple payback period shows how soon the option will pay for itself in savings (perhaps two weeks or four years), and is calculated by dividing the total capital investment (equipment and installation costs) by the expected operating cost savings per year (from reduced material, energy, water, labor and waste disposal costs). In the scoring system below, options with a high capital cost but rapid payback should therefore be considered as a *low cost* option:

- No or Minimal Cost - 4 points.
- Low Cost - 3 points.
- Medium Cost - 2 points.
- High Cost - 1 point.

**Comparing the Options** Once scores have been attributed to the environmental performance, implementation potential and costs of each option, they can be more directly compared, as shown below. Those options awarded the highest scores are more likely to be successful.

Modification	Environmental Performance	Implementation Potential	Cost of Option	<b>Total Score</b>
Option A	5	4	4	<b>13</b>
Option B	4	2	1	<b>7</b>

### **CONDUCTING AN ASSESSMENT – A SUMMARY**

- Obtain the commitment and support of top management, to establish a strategy and clear objectives.
- Formulate an *Action Plan* which identifies the focus of the assessment and allocate responsibility.
- Collect documentation, flow diagrams of processes, and relevant data .
- Establish the baseline using a mass balance to measure inputs and outputs.
- Identify opportunities for eco-efficiency through improved management and process technology.
- Evaluate options for using a systematic assessment of environmental performance, implementation potential, and option cost.

### **3 DEVELOPING PRACTICAL SOLUTIONS**

The methodology in the previous section shows how opportunities for eco-efficiency measures can be identified, quantified, and compared to each other for appraisal.

This section describes some of the areas where eco-efficiency measures have been adopted in the machinery and electrical equipment industry in the past. Basic guidelines are given for the three key areas in which these opportunities are commonly found:

- housekeeping and management;
- modifications to products and processes; and
- waste management.

#### **3.1 HOW GOOD IS YOUR HOUSEKEEPING?**

Housekeeping is a general term which is used to describe how well the day-to-day activities of a facility are managed. Housekeeping measures are not necessarily technical in nature; they include basic functions such as storage, stock control, record keeping, cleaning and maintenance.

Good housekeeping is essential for making sure that a business is run efficiently. In the same way, good housekeeping is also the first and most essential step to improving eco-efficiency. Housekeeping is therefore the first place a manager should look for opportunities to save resources, reduce waste and prevent pollution. Good housekeeping provides low-cost, low-risk and low-technology solutions for improving eco-efficiency and saving money. Areas where efficiency can be improved through improved housekeeping include:

- solvent use for cleaning and drying;
- purchasing and storage;
- measurement and calibration; and
- equipment inspection and maintenance.

Improving eco-efficiency through good housekeeping requires involvement from everyone working in the facility. This ensures that all employees understand the role they play, and may require some basic training to raise their awareness. The key messages to promote are that *wherever there is waste there is wasted money*, and that *their actions bear directly on the environment*.



### Solvent Use

A large proportion of the environmental problems associated with the machinery and electrical equipment industry arise through the disposal of process and cleaning wastes. Much of this waste constitutes various kinds of solvent, including halogenated and organic solvents, used during different process steps.

Solvent use (and the need for separate treatment) can be reduced considerably by exploiting opportunities for solvent re-use. For example, solvent which has cleansed printed circuit boards may be re-used to clean dirtier operations such as cleaning machine parts and degreasing computer parts. Such re-use can reduce costs for both solvent consumption and disposal considerably.

### Purchasing and storage

Badly managed purchasing and storage can lead to over-stocking and poor storage, with material lost through aging, spillage and contamination. Proper chemical handling begins with procedures for ordering, purchasing, and storing:

- obtain details about proper packaging, handling, chemical constitution, and control of impurities from the suppliers;
- use packaging designed to minimize spills (most bulk containers are effective);
- registering dates and quantities of all purchases on receipt to minimize surplus and spoilt orders;
- segregate chemicals (eg acidic, flammable, alkali, oxidizer) to prevent contamination;
- use proper racks, storage bins and bulk tanks with dikes or berms to contain leaks;
- store goods away from heavily trafficked areas to avoid container damage; and
- use a vacuum to clean-up powder spills, which under no circumstances should be washed down the drain.

### Measurement and calibration

Inaccurate measurement and calibration results in material waste, especially where too much material is used *just in case*:

- Measuring and dispensing devices should be routinely calibrated. Individual measuring vessels should be retained for each chemical, avoiding unnecessary washing.
- All chemicals should be accurately weighed, dispensed and mixed, avoiding spillage and waste. Mixing areas should be well lit and ventilated, with a smooth and sealed floor, and as close to the production area as possible.
- Wash small parts in a solvent bowl and filter and re-use the

solvent. Solvent can also be wrung from wet rags using an old laundry type wringer is ideal.

#### Equipment inspection and maintenance

The periodic checking of components (pumps, valves, filters, switches and regulators) will avoid inaccurate dispensing, leaks, filter clogging and off-quality production. Close attention should be paid to common defects such as missing guards, loose electrical cords, and leaks of water, steam and compressed air.

### **3.2 TECHNOLOGICAL MODIFICATIONS AND SUBSTITUTIONS**

Once the first step of improving housekeeping has been taken, the eco-efficiency assessment can move on to technology modifications and material substitutions. On the whole, such changes to the process require some capital investment, however savings in energy, water and material use can result in attractive payback periods, perhaps within a few months.

The easiest technologies to implement are often those proven in other industries. Such modifications are often made in the following areas:

- product design;
- chemical substitutions; and
- process and operational adjustments.

In each case, the design stage (of a product, the process and particularly a new facility) offers the unique and optimum opportunity for making change.

#### Product Design

*Life Cycle Analysis* is increasingly being used to assess the broad range of impacts associated with a product during its design. The analysis takes a "cradle to grave" approach, looking at the raw material use, transportation, packaging, impacts during use, and disposal or recyclability.

Manufacturers in some sectors, particularly the manufacturers of home appliances and office equipment, are beginning to apply this methodology in programs known as "*Design for the Environment*", "*Integrated Environmental Design*" and "*Product Stewardship*", which include:

- using materials with some recycled content;
- designing products which have reusable components;
- designing products for easy disassembly at its end of life;
- reducing the diversity of materials used to ease recycling; and
- implementing a product take-back plan.

Many of the recognized household names in home appliance and computer manufacturers have implemented such programs. Examples include the adoption of a “modular” design principle, where a single part (such as a printed circuit board) can be removed and replaced in the event of failure, rather than replacing the device completely. Equipment casings, for example those of some computers, have been redesigned to avoid metal fixtures and printed labels (by molding and pressing) to reduce material diversity and ease recycling after use. Another common area is in packaging, where recycled, recyclable and re-usable materials such as paper and cardboard can replace plastics such as polystyrene in packing for shipping and transportation.

Chemical Substitutions
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Machinery and electrical equipment manufacturing is a chemically intensive process, and the substitution of polluting chemicals provides a key focus for improving eco-efficiency. By substituting toxic and polluting chemicals for less harmful ones, health hazards and the need for treatment and disposal will be significantly reduced.

Opportunities for chemical substitutions will vary substantially between facilities because of differences in regulatory and environmental conditions, process conditions, products, and raw materials. Examples of chemical substitutions frequently applied in the machinery and electrical equipment industry are illustrated below.

### **COMMON CHEMICAL SUBSTITUTIONS**

- Cyanide plating solutions can be replaced by alkaline zinc or copper, or acid zinc or sulfate copper (among others)..
- Sodium bisulfite and sulfuric acid for ferrous sulfate in order to oxidize chromic acid wastes.
- Substitute liquid chlorine with gaseous chlorine to cut cyanide reduction.
- Replace hexavalent chromium with trivalent chromium plating systems.
- Replace cyanide with non-cyanide baths.
- Substitute beryllium oxide with aluminum nitride.
- Replace conventional chelating agents with sodium sulfides and iron sulfates in removing metal from rinsewater.
- Replace methylene chloride, 1,1,1, trichloroethane, and perchloroethylene (solvent base photochemical coatings) with aqueous base coating of 1% sodium carbonate.
- Replace methanol with non-flammable alkaline cleaners.
- Substitute hydrogen chloride for trichloroacetic acid.

#### **Operational and Process Changes**

Process adjustments may require production alterations during the design and planning stage of operations. The use of modern computer aided design and process software can allow for the testing of new concepts without the capital risk. These tools can also demonstrate problem areas of current activities open to eco-efficiency modifications. Operational adjustments typically involve the reduction in use, and recovery of materials from the production process. The following table presents a selection of the most generically applicable process and operational adjustments.

<b>Process</b>	<b>Eco-efficiency Alternative</b>
Semiconductor Wafer Fabrication	Adopt planar designs as these use significantly less chemicals during wafer fabrication.
Cleaning of Wafers	Vacuum packing immediately after epitaxy avoids the need for chemical cleaning prior to oxidation.
Photo-	Switch to positive photoresist material or screen

lithography	printing which avoids the use of solvents.
Semiconductor Packaging	Use laser marking to avoid the use of marking inks, which eliminates ink contaminants and cleaning solvents.
Circuit Board Manufacture	Use dry plasma etching or thinner copper cladding to reduce chemical use and eliminate process steps, improving efficiency.
Circuit Board Assembly	Switch to surface mount technology which reduces solder and solder cleaning, and results in higher density packing.
Cleaning and Surface Preparation	Use abrasives or countercurrent cleaning to improve rinse efficiency and reduce solvent in effluent.
Electroplating	Reduce drag-in and drag-out through proper rack design, increase water temperature and control, install mechanical agitation and filtration to extend bath life and increase efficiency.
Electroplating	Decrease withdrawal rates or use demineralized water as makeup.
Electroplating	Use closed circuit rinses or spray rinses, de-ionized water, fog nozzles, or increased agitation to improve rinse efficiency and reduce effluent.

### **3.3 WASTE MANAGEMENT**

Opportunities for recycling can be increased through the proper segregation of wastes, either through good housekeeping measures, or through process and technology modifications. Proper segregation of waste streams facilitates the recycling of wastes back into your process, thereby reducing waste and raw materials. Additionally, valuable or useful wastes may be reclaimed from waste streams and sold off-site as raw materials.

A selection of recycling opportunities for the machinery and electrical equipment industry are provided below.

***RECYCLING IN THE MACHINERY &  
ELECTRICAL EQUIPMENT INDUSTRY***

- Send drag out waste to another company for waste exchange.
- Reuse drag-out waste within the process.
- Evaporate and concentrate rinse baths for recycling.
- Recover and reuse solvent vapors by condensation and/or compression.
- Convert sludge for use as smelter feed to recover metals.
- Install a closed loop batch treatment system for rinsewater to reduce water use and waste volume.
- Oxidize cyanide and remove metallic copper to reduce metal concentrations.
- Recover process chemicals with “fog rinsing” of parts whilst over the plating bath.
- Use ion exchange and electrowinning, reverse osmosis, and thermal bonding to maximize materials recovery.
- Use hydrometallurgical processes to extract metals from sludge.
- Remove and recover lead and tin from boards by electrolysis or chemical precipitation.
- Install an electrolytic cell (this can recover 92% of dissolved copper in drag-out rinses) and an atmospheric evaporator (which can recover 95% of chromic acid drag-out. Recycle it into chromic acid etch line).

## **4 MONITORING YOUR PROGRESS**

Once measures for eco-efficiency have been implemented, it is critical that progress is continually monitored. This is the key to identifying whether the initiatives are in fact producing the cost savings that were anticipated, and hence whether the objectives of the eco-efficiency program have been met.

In addition, monitoring is the only way to establish whether the performance targets which you have established are being achieved. This information provides the basis for setting targets in the future, and also helps identify where the implementation of subsequent eco-efficiency measures can be improved.

The following gives a simple checklist which can be used to assess the overall benefits of the eco-efficiency program. As mentioned above, this should be supported with more detailed records of material, water and energy consumption, and waste disposal charges.

### **THE ECO-EFFICIENCY EVALUATION CHECKLIST**

Taking all costs into account, have unit costs of production fallen?

Are you still ordering the same quantity of raw materials?

Has there been a reduction in energy costs?

Has unit output remained static?

Have you received the same amount of violation notices?

Are you selling any new products?

Are you selling more of the same products?

Have waste handling and/or shipping costs remained static?

Have waste disposal charges decreased?

Are you discharging less effluent and air emissions?

Is there any reduction in the number or work-related accidents?

Has your program had any effect on the number of worker absentee days?

Is there a lower turn over of staff, perhaps through improved working environment, conditions, and moral?

## Overcoming Obstacles and Maintaining Your Program

### ***HELP!!***

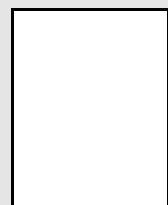
- Contact local government and ask about pollution prevention
- Find out what local and international Trade Associations are doing.
- Local universities and colleges are often eager to participate.

Nearly all eco-efficiency programs depend upon the commitment of you and your staff for their success, continuation and advancement. You must therefore disseminate and publicize stories of success and acknowledge your efforts and their efforts in its contribution. You should also allow for the development and implementation of new ideas and techniques.

**GOOD LUCK .....and avoid conclusions, such as "there are no cost saving or environmental opportunities at my facility".**

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