1 – Background Material

1 Textbook

1.1 Purpose of the textbook "Cleaner production and waste minimization"

Purpose of the textbook

After having worked with the present textbook you will be able to:

- Tell the difference between the cause and effect of waste and emission problems;
- Recognize the economic benefits of waste and emission minimization;
- Identify waste and emissions in a company;
- Define the factors influencing waste and emission minimization;
- Use the worksheets to find systematic solutions to a company's waste and emission problems.

Procedure

The textbook contains detailed information on the following topics:

- Definitions (waste, emissions, etc.);
- Traditional environmental management versus a more holistic approach;
- Interrelations between raw material, production process and waste/emissions;
- Factors influencing the generation of waste and emissions (where to start from);
- Data collection as a basis for the minimization of waste and emissions;
- Defining categories for waste and emissions together with strategies to minimize them.

Data collection – as an essential basis for comprehensive information on emissions and waste in a company – can be very time consuming. On the other hand, it is possible, especially in larger companies, to obtain the data immediately from the computer system.

1.2 What is CLEANER PRODUCTION?

What does CLEANER PRODUCTION mean?

CLEANER PRODUCTION is defined as the continuous application of an integrated preventive environmental strategy to processes, products and services in order to increase the overall efficiency and to reduce risks to human life and the environment.

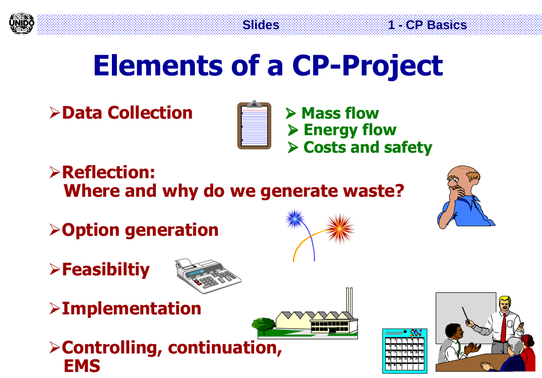
- In production processes, cleaner production addresses the saving of raw materials and energy, the elimination of toxic raw materials and the reduction in the quantities and toxicity of waste and emissions.
- In product development and design, cleaner production addresses the reduction of negative impacts throughout the life cycle of the product: from raw material extraction to ultimate disposal.
- In services, cleaner production addresses the incorporation of environmental considerations into the design and delivery of services.

As mentioned before, cleaner production is the continuous application of a preventive strategy and methodology (Source: UNEP).

Helping companies to help themselves.

In this context it is important to mention that the workers know their company best and that this expert know-how is essential. External knowledge can and shall only help them to find solutions. Thus cleaner production is above all a stimulation of new ideas by an external view.

A cleaner production project follows a certain methodology and consists of the following elements:



1. Data collection – mass flow, energy flow, costs and safety

The adequate description of the status quo is one of the basic and most important steps but often time consuming. The better the actual procedures and data are known, the more adequate CP options can be implemented.

2. Reflection: Where and why do we generate waste?

After their collection, the data are analysed and assessed according to the principles of cleaner production.

3. Option generation

Taking the analysis as a starting point, CP options are generated. New, creative and/or already well-known options will come up, aiming at a reduction at source by good housekeeping, product or process modification, organizational changes, internal or external recycling.

4. Feasibility analysis

For the selected options, a feasibility study will analyse the economic, technical and environmental feasibility.

5. Implementation

In this step CP options are implemented. Steps 1 to 4 may be carried out previously, but if the advantages and feasibility are obvious, options are often directly implemented without a detailed feasibility analysis.

6. Controlling and continuation

Probably the most important and challenging aspect is the establishment of a systematic procedure for on-going improvement. In this case, the tools of environmental controlling are used to set up new goals and targets and to ensure their continuous implementation.

The company analyses used in a cleaner production project or programme may be applied to five different kinds of evaluations:

Evaluation of the company analysis		**For use by**
Regular report, environmental controlling	⇒	Management
Waste management plan	⇒	Authorities, company
Analysis of environmental/economic weak points	⇒	Personnel/management
Environmental management system (ISO 14001)	⇒	Business partners/customers
Environmental report	⇒	Public

1.3 What is waste and what are emissions?

Minimizing waste and emissions means...

Waste and emissions are – mostly very expensively acquired – raw and process materials that have not been transformed into marketable products or into raw materials to be used as inputs into another production process. They include all solid, liquid and gaseous materials which are emitted into the air, water or soil as well as noise and waste heat. The production process also comprises activities that are often forgotten, such as maintenance, servicing, cleaning and the office area.

to increase the environmental efficiency of a company ...

Therefore minimizing waste and emissions also means increasing the degree of utilization of the materials and energy used for production (increasing the environmental efficiency) until, and this is the ideal case, a 100 percent utilization guarantees a waste and emission free process.

to benefit from commercial advantages ...

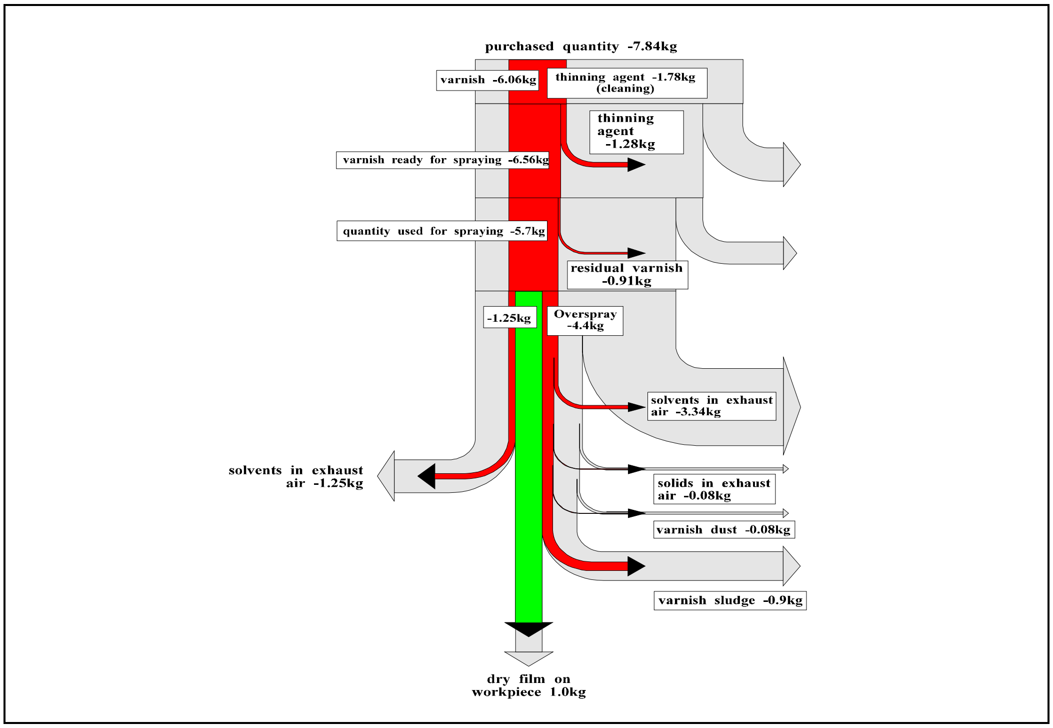
For the company, waste minimization is thus not only an environmental goal but even more importantly it is a commercially oriented programme to increase the degree of utilization of materials.

and to save costs of raw materials.

This situation can also be illustrated by the fact that even though the treatment and disposal of waste and emissions is very expensive, the costs due to the loss of raw materials (which are wasted in the proper sense of the word) are normally much higher.

Example: *Applying a repair coat to a car can be a very material intensive process. Using a conventional, solvent-containing varnish with a non-volatile matter content of about 60% combined with an uneconomic spraying application from a beaker pistol which is inadequately handled and badly regulated by the painter, the application of 1 kg of varnish on the material consumes a quantity of about 10 kg of raw material.*

Opting for a varnish with a higher non-volatile matter content together with the use of a high-volume-low-pressure spraying pistol, a metering pump during application and an improved cleaning system for the spraying pistol – the best available technology – brings the consumption of raw material required for the application of the same paint film down to slightly more than 2 kg (see below). Based on disposal costs of about € 1 per kilogram and material costs of € 15 per kilogram, considerable savings are achieved, which can be deducted from the investment costs.


purchased quantity -7.84kg
varnish -6.06kg
thinning agent -1.78kg (cleaning)
thinning agent -1.28kg
varnish ready for spraying -6.56kg
quantity used for spraying -5.7kg
residual varnish -0.91kg
-1.25kg
Overspray -4.4kg
solvents in exhaust air -3.34kg
solvents in exhaust air -1.25kg
solids in exhaust air -0.08kg
varnish dust -0.08kg
varnish sludge -0.9kg
dry film on workpiece 1.0kg

1.4 Cleaner production versus end of pipe?

Environmental protection should mean more than shifting problems

Up to now, conventional environmental technologies have been mainly limited to the treatment of existing waste and emissions (examples: air filter technology, wastewater treatment, treatment of sludge, waste incineration etc.). As this approach intervenes at the end of the production process, it is also referred to as end-of-pipe technology. It is essentially characterized by additional expenses for the company and a shifting of problems (examples: production of sewage sludge by wastewater treatment, production of gypsum from flue gas, etc.)

Cleaner production means integrating environmental objectives into the production process

Cleaner production aims at integrating environmental objectives into the production process in order to reduce the quantity and toxicity of waste and emissions and thus to cut costs. Compared to the disposal by external services or to end-of-pipe technologies, it presents several advantages:

- As cleaner production reduces the quantity of materials and energy consumed in the production process, it favours economic solutions.
- Due to an intensive exploration of the production process, the minimization of waste and emissions generally induces an innovation process within the company.
- Responsibility can be assumed for the production process as a whole; risks in the field of environmental liabilities and of waste disposal can be minimized.
- Waste and emission minimization is a step towards a more sustained economic development.

While conventional waste management asks:

What can we do with existing waste and emissions?

Cleaner production in the sense of production integrated environmental protection asks:

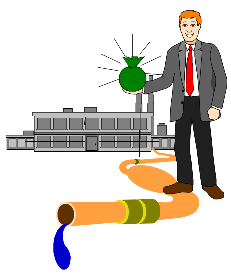
Where do our waste and emissions come from?
Why have they turned into waste at all?

From the symptom to the source

Therefore the essential difference lies in the fact that cleaner production does not simply treat the symptom but that it tries to identify the source of the problem.

Example: *In the water treatment unit of a copper manufacturer, mud containing metal is produced, which should be marketed because of increasing disposal costs. Marketing turns out to be quite difficult due to the fact that the mud contains too much iron.*

Further investigation reveals that the iron is added only later in considerable amounts. It is introduced into the wastewater treatment unit in form of iron chloride (as a typical flocculant). Thus the company realizes that its problem is not so much a mud problem but rather a wastewater problem.



A further analysis of the principal wastewater sources has shown that at two points of the production process an enourmous quantity of electrolytical copper in solution is consumed and consequently ends up in the wastewater. The mud or wastewater problem has finally turned out to be a process problem. Relatively simple measures on both organizational and technological levels finally helped to considerably reduce the consumption of raw materials at these two points, thus leading to a 50% reduction in the mud produced.

A further characteristic of cleaner production is that a company is regarded as an entity. Raw materials, energy, products, solid waste as well as emissions into the water and the air are closely intertwined via the production process.

The following table summarizes the differences between end-of-pipe technologies and cleaner production in the sense of production-integrated environmental protection.

End-of-pipe technology	Cleaner production
How can we treat existing waste and emissions?	Where do waste and emissions come from?
... stands for re-action.	... stands for action.
... generally leads to additional costs.	... can help to reduce costs.
Waste and emissions are limited by means of filters and treatment units. End-of-pipe solutions Repair technology Storage of emissions	Waste and emission prevention at source. Avoids potentially toxic processes and materials.
Environmental protection comes in after the development of products and processes.	Environmental protection comes in as an integral part of product design and process engineering.
Environmental problems are solved from a technological point of view.	Environmental problems are tackled at all levels/in all fields.
Environmental protection is a matter for competent experts.	Environmental protection is everybody´s business.
... is bought from outside.	... is an innovation developed within the company.
... increases material and energy consumption.	... reduces material and energy consumption.
Increased complexity and risks.	Reduced risks and increased transparency.
Environmental protection is reduced to fulfilling legal requirements.	Environmental protection as a permanent challenge.
... is the result of a production paradigm dating from a time when environmental problems were not yet known.	... is an approach intending to create production techniques for a more sustainable development.

A further detailed differentiation of terms such as clean technologies, cleaner production, sustainable technology, production-integrated environmental protection, etc. cannot be made in this textbook. However, they correspond to the principle of integrated environmental protection as discussed above.

In addition to the arguments mentioned above in favour of cleaner production, other advantages are as follows:

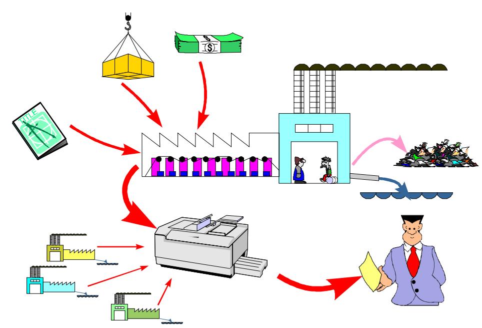
- Avoiding increased costs due to waste treatment;
- Less susceptible to bottlenecks (disposal space, export licences, incineration capacities, etc.);
- Less problems due to liabilities;
- Better image;
- Less protests from neighbours.

1.5 Which factors are at the origin of waste and emissions?

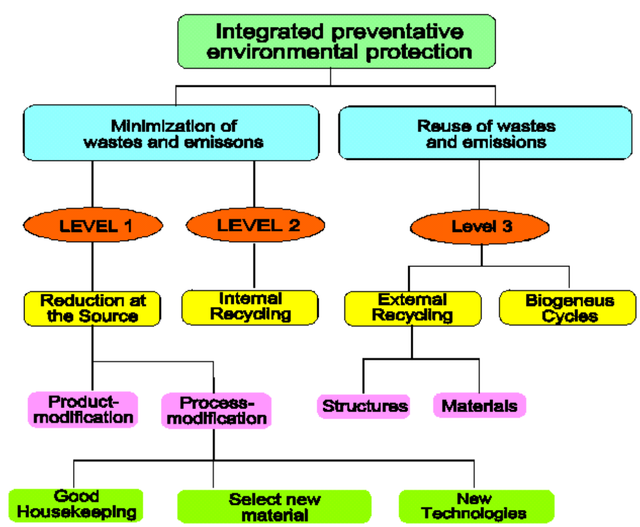
The environmental situation does not only depend on the technology used

When asked about factors influencing the generation of waste and emissions, you will probably first think of the technology used in the company. Certainly, technology does play an important role in this context. But this should not lead to the conclusion that only technological measures can help to achieve efficient and clean production. There is a multitude of various other fields to be taken into account. The main factors at the origin of waste and emissions are the following:

- Personnel;
- Technologies;
- Raw materials;
- Products;
- Capital;
- Know-how/processes;
- suppliers/business partners.



On the basis of these factors, various levels and strategies aiming towards cleaner production and waste minimization are possible.



Experience from the past as well as evaluations of different projects show the following:

Priority to measures tackling the problem at source ...

The major goal is to find measures to tackle the problem at source (level 1). These include modifications of both the production process and the product itself.

- **Product modifications** can lead to a highly improved environmental situation in terms of production, utilization and disposal of the product. They may lead to the substitution of the product by another, to increased longevity by using different materials or changing the product design. In this context, the term "ecological design" has gained in importance in recent years. However, many companies are very reluctant to modify their products.

- **Process modifications** can reduce waste and emissions considerably. The term "process" comprises the entire production process within a company including the following measures:

Good housekeeping of raw and process materials, including changes at the organizational level: in most cases these are economically the most interesting measures and can be put into practice very easily. They may include personnel training and motivation, changes regarding the operation of equipment, handling instructions for materials and containers, etc.

Substitution of raw and process materials: Raw and process materials which are toxic or otherwise difficult to recycle can often be substituted by less harmful ones, thus contributing to reduce waste and emission volumes.

... only then consider internal recycling ...

Technological modifications: These may range from simple reconstruction activities to comprehensive changes of the production process including energy saving measures.

Waste products that cannot be avoided by the measures described above should be re-integrated into the production process of the company (internal recycling, level 2). This includes:

- Recycling back into the original production process;
- Recycling of products to be used as inputs into another production process;
- Further exploitation for a different, minor purpose (downcycling); or
- Recovery and partial use of a residual substance.

...or external recycling

Only if you have considered all the measures listed above should you opt for the recycling of waste and emissions outside the company (level 3), for instance, in the form of external recycling or of a re-integration into the biogenic cycle (e.g. compost). The recovery of valuable materials and their re-integration into the economic cycle – such as paper, scrap, glass, compost materials – is a less widely recognized method of integrated environmental protection by means of waste minimization. This is essentially due to the fact that this approach does not contribute to further reducing the amount of materials used in the company.

As a rule, one can say that the closer you get to the root of the problem and the smaller the cycles are, the more efficient the measures will be.

1.6 Data collection: the basis for cleaner production

Data are the basis of planning

In order to detect appropriate measures for cleaner production, an overview of the major material flows within a company has to be established, if possible by using an up-to-date database.

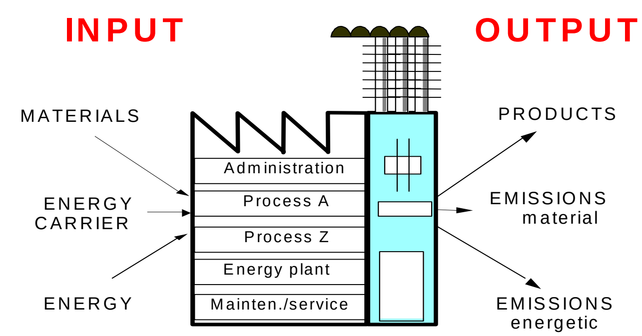
Before collecting data, answer the following questions:

- Which data do I need?
- Where do I get them from?
- Which information sources exist in a company?

First of all determine for which areas of a company data should be collected. On this basis you can define which data you will need. Ideally, you should consider the company as a whole, however, it might be useful to omit certain areas.

Examples of typical areas:

How to define the limits of an energy balance



Mass and energy are constant

By defining the areas where measures have to be implemented you determine the limits of the energy balance. The principle of conservation of mass and energy states that any material entering an observed scope of balance also has to leave it: the difference is either stored or transformed into another material. That means that everything a company has to dispose of had to be purchased before.

Within an industrial production company, all materials and energy resources can be monitored at three points:

- At the point of entry into the balance scope – i.e. at the moment they are bought;
- At the point of leaving the balance scope – i.e. the product in the form of emissions, waste, waste heat;
- At the point of use – at the production unit, as final product.

On the basis of the principles of conservation mentioned above, the quantity measured at point 1 should equal the sum of the quantities measured in points 2 and 3. However, this is a rather theoretical concept. You will see that in reality it is rarely possible to verify these principles.

And here arises another question:

Do the collected data correspond to reality?

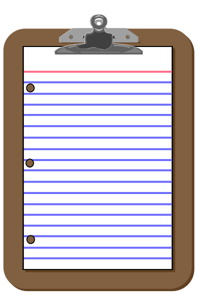
In most cases, one tends to underestimate the importance of this question. Severe problems actually occurred due to unverified data. As an example, the data stored in accounting (purchasing department) do not always correspond to the quantities that were consumed in reality.

How to collect and verify data

Working documents available from diverse information sources can vary in quality:

For materials entering the balance scope:

- Documents on accounting and costing;
- Delivery notes;
- Documents from suppliers on product composition;
- Internal book-keeping of packaging;
- ...



For materials leaving the balance scope:

- Product lists and sheets of product composition;
- Internal documents on waste and emissions, delivery notes;
- Invoices of disposal firms;
- Documents from the wastewater authority;
- ...

In-site use:

- Allocation to cost centres;
- Measures carried out at machines and installations;
- Information of personnel on working time and shift changing intervals;
- Lists of parts;
- Sheets of product composition;
- Machine specifications;
- Model identifications;
- ...

As it appears, information can never be complete at any of those points. For example, take the materials entering the balance scope: data on containers are only very rarely available. Very often, the designation of a product (e.g. detergent) does not suggest in any way its chemical composition. As for goods leaving the balance scope, information on volatile matters is missing in most cases (evaporated solvents, waste heat) as well as information on the composition of the products.

What should you know after having collected the data?

After having collected all data you should be able to answer the following questions:

- How much raw and process material, how much energy do we use?
- How much waste and emissions are produced?
- Which part/s of the process do they come from?
- Which waste products are hazardous/have to be controlled and why?
- Which portion of the raw or process material becomes waste?
- Which portion of the raw or process material is lost in the form of volatile emissions?
- What are the costs incurred due to waste disposal and the loss of raw materials?

However:

It's a long way to Tipperary and maybe you are only at the beginning.

1.7 How to proceed systematically to minimize waste and emissions

Which mass flows within the company are particularly important?

In order to work systematically on the minimization and avoidance of waste and emissions, it is important to know the most important mass flows in a company. In this case the term "important" may have several meanings:

- Important in terms of legal regulations;
- Important in terms of large quantities;
- Important in terms of high costs;
- Important in terms of toxicity and environmental effects.

As a working period one can choose a calendar year. For the worksheets, please refer to the respective section of the Toolkit.

Worksheet 1-1: Main products/services

What does the company produce?

Enter the main products or services in Worksheet 1-1. If other measuring units are used in the company (such as batches, metres, cubic metres, etc.), convert the quantities as far as possible into kg.

Worksheet 1-2: Main raw and process materials

What percentage of the raw and process materials is used for production?

Record the main raw and process materials used in a company in Worksheet 1-2 and indicate their quantity, specific and total costs as well as their use. In addition, try to determine the percentage of any raw material used for production. Depending on the material, this may vary from 0 to 100%. If there are no exact documents or measuring data available, try to give a reliable estimate. Please do not forget water and air, two elements that are often overlooked in this context. In addition, process materials such as lubricants, paints, solvents, detergents, etc. should be included in Worksheet 1-2.

Worksheet 1-3: Energy data

Enter data on energy consumption, such as electricity, heating oil, gas, district heating, etc.

Worksheet 1-4: Main types of waste and emissions

Wastewater and waste air must be considered

This worksheet refers to the main types of waste and emissions arising in a company. It is important to include wastewater and waste air. In addition to the quantities produced, there are also questions on specific purchasing and disposal costs – please indicate in money unit per quantity unit. The total costs in money units are then calculated by multiplying the specific costs by the quantity.

Which materials used in a company are particularly dangerous?

Worksheet 1-5: Prevention of waste and emissions

After having collected the basic data, define measures to minimize or even totally avoid waste and emissions as well as solutions for other problem areas. Worksheet 1-5 contains a systematic overview of the main approaches (partly illustrated by simple examples). Tick the measures listed in Worksheet 1-5 that you consider useful for your purpose.

Tip: *Use Worksheet 1-5 as a brainstorming aid and tick everything you consider useful. Try to get away from the beaten track of ideas and strategies you may have developed.*

How to define measures to minimize them

Enter the waste and emissions from Worksheet 1-4 as well as other problem areas you might think of (e.g. because of raw materials used) in the column heading of Worksheet 1-5.

In many cases measures to avoid or minimize waste and emissions cannot be clearly assigned to one or more columns. However, this is not a great problem for your further work.

Worksheet 1-6: Possibilities of minimizing waste and emissions in a company

Possibilities of avoiding waste

Worksheet 1-6 lists measures for minimizing waste and emissions. Some of them have already been put into practice and are mentioned as examples. One example can be allocated to several categories, e.g. technological modifications can be accompanied by a change of raw materials and personnel training.

Worksheets 1-7 and 1-8

At the beginning of company work, Worksheet 1-7 (Our environmental situation) can be used to point out which areas have a potential for improvement. This is, however, only a qualitative evaluation. As a next step, the goals for waste reduction are entered in Worksheet 1-8 (Quantification of goals). For further information on the use of Worksheets 1-7 and 1-8, please refer to the exercise section of Volume 1.

1.8 Classification of waste according to its origin

Waste and emissions can originate from different raw materials for different reasons. By establishing a list of possible origins, waste and emissions can be classified accordingly. The table below contains 11 categories. For each category, various strategies can be applied to avoid or minimize waste or emissions. The avoiding strategies described below may serve as an example to illustrate which type of measure could be applied to a certain type of waste.

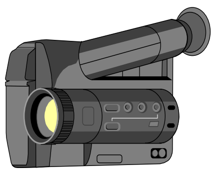
Main categories of waste and typical solutions

C*	CATEGORY OF WASTE	EXAMPLES	TYPICAL SOLUTIONS
A	Raw materials, not used	Plate scraps, paper blanks, varnish residues, dyeing agents in wastewater from textile producers	Changes in technology, automation, thoughtful use, personnel training, use of different raw materials, improved stock-keeping, etc.
B	Impurities/secondary substances from raw materials	Ash from combustion, oil and grease on metal plates, skins and seeds in fruit processing	Use of different raw materials, search for further exploitation possibilities
C	Undesired by-products	Gypsum from flue gas precipitation, mud from wastewater treatment	Re-utilisation as a new product, technological improvement, process changes
D	Used process materials	Oils, solvents, paintbrushes, catalysts	Internal recycling, cleaning and maintenance, checking of dosage
E	Substances produced at start-up or shut-down	Non-commercial products, only partly filled containers	Improved operations scheduling, personnel training, improved technology, larger production batches, internal recycling
F	Reject batches, refuse	Non-commercial products	Improved technology, personnel training, automation, quality assurance
G	Residues and materials from maintenance	Filter cloths, lubricant oils, cleaning rags	Improved serviceable life, different raw materials, outsourcing, maintenance
H	Materials from handling, storage, sampling, analysis, transport	Residues from the lab or from container cleaning, spoiled or damaged goods	Check logistics, outsourcing
I	Losses due to evaporation	Loss of solvents due to open containers, evaporation during varnishing/cleaning etc.	Personnel training, thoughtful use, different raw materials

C*	CATEGORY OF WASTE	EXAMPLES	TYPICAL SOLUTIONS
J	Materials from defects and leakages	Oil fixing agents, impurities in raw materials or products due to inexpert handling, loss of heat (leakage)	Qquality assurance, improved maintenance, automation, training
K	Packaging material	Cardboard, foil, pallets, etc.	Purchasing directives, returnable packs, recycling

1.9 Cleaner production solutions and examples

1.9.1 Product modification



Product modification can be an important approach although sometimes hard to realize. The most widely accepted argument against changing a product is the consideration of customer preferences. Product modification may include:

- **Substitution of a product**

Examples: *instead of offering a certain quantity of energy, an energy supplier offers the insulation of buildings; solar cells instead of batteries for pocket calculators; energy-saving light bulbs.*

- **Increased longevity**

Examples: *accumulators instead of batteries; increased product longevity through improved corrosion protection.*

- **Change of materials**

Example: *aerosol substitutes in refrigerating agents.*

- **Modification of the product design**

Examples: *special furniture design to minimize cuttings; modular design allows easier access for repair purposes.*

- **Use of recycled materials**

Examples: *leather fibre scraps as filling material in leather production; granulated recycled plastic for the production of bumpers.*

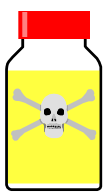
- **Avoidance of critical components**

Example: *asbestos as heat insulator in irons.*

- **Improved possibilities of returning products**

Examples: *the electronic part of the energy saving bulb is kept, only the tube is changed; module systems ensure easier disassembly and return of products.*

1.9.2 Substitution or change of raw and process materials



There is a whole range of possibilities available for substituting or changing raw or process materials which include the following measures:

- **Substitution of organic solvents by aqueous agents**

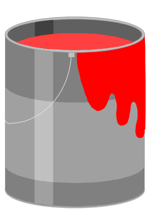
Examples: *hydrosoluble varnishes, water-based alkaline cleaning agents for metal degreasing.*

- **Substitution of halogenated solvents**

Examples: *substitution of aerosols in cleaning units, in the production of insulating materials and cooling units; halogen-free hydrocarbon solvents in dry cleaning instead of perchloroethylene (per).*

- **Substitution of petrochemical by biochemical products**

Examples: *cleaning agents on a soy or rape basis; natural dyeing substances instead of dyeing agents with petrochemical basis; lubricants on a biological basis.*



- **Selection of materials with less impurities**

Examples: *fuels containing less sulphur (natural gas instead of coal); minerals containing less hazardous substances; use of clearly separated corrugated board in the packaging industry; use of de-ionized water to prepare process solutions.*

- **Use of residues as raw materials**

Example*: use of fibre sludge from chemical pulp production for the brick industry, products from recycled materials (glass, paper, etc.).*

- **Use of biodegradable materials**

Example*: biodegradable detergents.*

- **Reduction in the number of components**

Examples*: less plastic in car manufacture; use of standardized screws for assembly of do-it-yourself furniture.*

- **Use of alternative energy sources**

Example*: natural gas or renewable sources of energy (solar energy, water power, biomass) instead of coal or oil.*

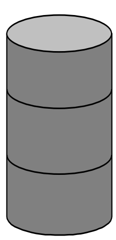
- **Use of heavy-metal free substances**

Example*: heavy-metal free substances in paints and varnishes (especially lead and cadmium).*

- **In general: use of less toxic materials**

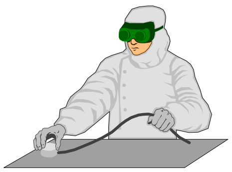
Examples*: cyanide-free galvanizing; chromating on the basis of chrome (III) instead of chrome (VI).*

- **Returnable packs**



Examples*: use of 1000 l returnable skeleton containers rather than 70 l throw-away packs; use of compostable packaging and/or filling materials (on the basis of pulp/paper or vegetable starch); cloths for furniture transport; packing units of the correct size (neither too big nor too small); complete emptying of packs.*

1.9.3 Technological and process modifications



A wide selection of technological modifications can be applied to improve the production process ranging from relatively simple reconstructions to time and energy-saving changes of the entire production process. Quite often these measures have to be combined with improved housekeeping and the use of modified raw materials. The following examples illustrate the wide range of possible technological modifications.

- **Substitution of thermo-chemical processes by mechanical alternatives**

  Examples*: cleaning of surfaces with brushes or supersonic methods rather than with acid or alkaline solutions; engraving instead of chemical etching.*

- **Use of countercurrent rather than single-cascade techniques**

  Examples*: countercurrent cascades in washing processes; countercurrent method in drying units; heat integration in processes with different temperatures; stripping of product carriers in two steps.*

- **Separate management of waste and wastewater streams**

  Examples*: the separate management of wastewater streams permits the electrolytic recovery of metals; separate waste collection facilitates both internal and external recycling.*

- **Improvement of process conditions**

  Examples*: varying pressure and temperature helps to increase the production yield; use of appropriate catalyzers.*

- **Increase in energy efficiency, use of waste heat**

  Several measures can be taken to increase energy efficiency:

  a) Improvement of insulation

  Example*: insulation of the heat source and/or of the point of consumption.*

b) Reducing losses during distribution

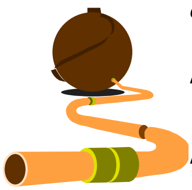
Example*: insulation of pipes*

c) Heat recovery

Example*: preheating of the air with hot flue gas; use of flash vapours*

d) Capacity management

Example*: stopping certain units at peak times, such as air extraction fans, etc.*



e) Cogeneration of heat and electricity

Example*: combined heat and power plants for the cogeneration of heat.*

f) Turning off lights and heating outside working hours

Example*: e.g. by movement detectors.*

g) Use of energy-efficient machinery with speed control

Example*: for feed pumps, ventilation, flue gas fans etc.*

- **Airtight sealing of equipment**

  Example*: metal protection of trichloroethylene cleaning equipment.*

- **Recovery and reuse of materials (water)**

  Examples*: by changing the water tubing, the rinsing water of an acid pickling bath can be reused for rinsing the preceding alkaline degreasing bath; directing the rinsing water circuit through an ion exchanger.*

- **Improved life time of chemicals or materials**

  Examples: *treatment of cooling lubricant emulsions with ultrafine filtration, pH and bacteria regulation; use of high performance fine oil filters in car maintenance.*

- **Reducing the infiltration of impurities**

  ***Examples**: covering of process baths; careful cleaning of storage areas.*

- **Modification of the work flow/omission of a process sequence**

In some areas the – often justified – question arises whether it is possible to change the work flow by omitting one sequence of the production process, thus avoiding the generation of waste right from the beginning.

***Examples**: no intermediate greasing of metal plates; no chrome plating of metal parts which will be treated with an anticorrosive coating anyway; no priming; no unnecessary drying procedures.*

1.9.4 Good housekeeping and operation

These measures are highly efficient because in most cases they involve low investment costs coupled with a significant saving potential. Besides the thoughtful use of raw and process materials they include all types of organizational measures.

Change in the dosage/concentration

***Examples**: reducing the temperature of a degreasing bath; changing the pH values of solutions; checking if the concentration of chemicals can be reduced; introducing a rinsing water regulation.*

- ***Better use of process capacities***

***Examples**: fully filling the drying unit; creating buffer capacities to operate machinery continuously at full rate (thus avoiding unnecessary losses due to a reduced operating rate); turning off temporarily unused equipment and machinery.*

- ***Reorganization of cleaning and maintenance intervals***

***Examples**: less cleaning stages in batch yoghurt production; monitoring of oil-changes with regard to time intervals, working hours and quality assurance.*

- ***Avoiding losses due to evaporation and leakage***

***Examples**: emptying sealed barrels with hand pumps.*

- ***Improved purchasing, storage and delivery***

Examples: *refusing leaking barrels; refusing unnecessary varnish samples; internal transport in closed circuits (tubes).*

- **Improved waste logistics**

The improvement of waste logistics and waste separation facilitates closed circuits, recovery and reuse, and minimizes disposal costs and cleaning expenses.

Examples: *newly designed waste collection points in assorted colours; separate waste collection in the workplace.*

- **Improved information**

The information flow can be improved by raising awareness, providing additional training, distributing operative instructions elaborated taking into account cleaner production, increasing cost transparency, including environmental costs in the company's accounting documents, defining environment-related responsibilities and cooperating with the responsible for environmental controlling.

Examples: *personnel education; information through a "green corner"; nominating people responsible for environmental matters and waste in each department; collecting ideas; setting up teams in charge of environmental matters; computerizing the use of materials.*

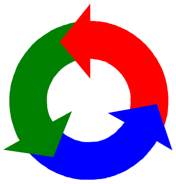
- **Standardization/automation**

Examples: *automation of the process of taking racks out of a galvanic bath to avoid loss through dripping; predefining cleaning intervals; predefining colours and tools.*

- **Improved purchase control**

Example: *reducing the number of different detergents.*

1.9.5 Closing internal loops



Closing internal loops involves, among others, the following measures:

- **Reuse: Renewed use of materials or products for the same purpose as before**

  Examples: *recovery of solvents used for the same purpose, returnable packs; washing cleaning rags; electrolytic or chemical recycling of caustic chemical solutions.*

- **Further use: Use of materials or products for a different purpose**

  Examples: *use of varnish residues for paintspraying invisible parts (e.g. for undersealing).*

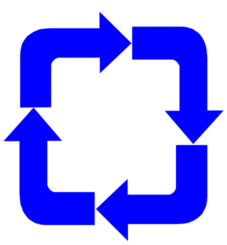
- **Downcycling: Further exploitation of a material for another purpose, generally of lower quality**

  Example: *plastic or paper residues as fillings for packaging.*

- **Recovery: Partial use of a residual substance**

  Example: *recovery of silver from photochemicals.*

1.9.6 External recycling



The measures described above apply also to external recycling although it is generally preferable to create closed circuits within a company. In this context it is also important to know whether you are dealing with real recycling or with downcycling, which in principle does not solve the disposal problem but only postpones it.

Examples: *recovery of aluminium and glass; recovery of metal from wastewater; use of plastic in noise protection walls and for park benches.*

Furthermore we can distinguish between:

- **Renewed use of whole structures**

  Examples: *containers as containers, pallets as pallets;*

- **Use of different materials**

  Example: *waste paper, scrap as a raw material for production.*

- **Use of materials for energy recovery**

  Example*: pallets as firing material.*

In addition to recycling in the proper sense of the word, external recycling may also include the re-integration of waste into biogenic circuits.

Example*: composting of labels from the cleaning process of milk and beer bottles.*

Taking into account these suggestions for the minimization and avoidance of waste and having identified specific approaches for a company, it is now time to elaborate more detailed solutions and to carry out a first simple evaluation using Worksheet 1-5.

The potential reduction in quantities and costs and the feasibility of the identified measures can only be evaluated after a more detailed input-output analysis. For details please refer to Volume 4 of the Toolkit.

The worksheet section of Volume 5 provides additional tools to evaluate the potentials of waste minimization.

1.9 Further information on cleaner production

Yaacoub, A., Fresner, J., Half is enough – An Introduction to Cleaner Production, ISBN 3-9501636-2-X, LCPC-Press, Beirut, 2006, available from the Lebanese Cleaner Production Center (ali.yaacoub@lebanese-cpc.net)

Software for drawing Sankey diagrams:

www.sankeyeditor.net