MOED

Minimisation Opportunities Environmental Diagnosis

Ministry of the Environment
Spain

Autonomous Government
of Catalonia
Ministry of the Environment
Centre for Cleaner
Production Initiatives

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Table of contents

Prologue

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Mediterranean Action Plan[2]

The integration of the environment in all aspects of life in society is currently an undeniable fact, which is accepted as permanent, regardless of the differences that may exist in the rhythm and speed at which this integration takes place in a given situation. The change in individual or associative norms of behaviour this brings about undoubtedly affects all the segments into which we could divide a society or country, and within them, the fabric of businesses and economic sectors.

In the case of businesses, this change, this necessary adapting to the scenario appearing in the light of this integration of the environment, should be seen as a new factor of production that the company should incorporate into its management system on the correct integration of which its future viability will depend.[3]

If we go over the stages that have linked together in the relation between company and environment[4] and which have evolved, let us not delude ourselves, depending on the stricter compliance demanded by environmental offices and authorities, we can appreciate that there is a point of inflexion from which, that which may have been considered, wrongly and merely, an additional expense, could be a source of competitive advantages.

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[1] The Regional Activity Centre for Cleaner Production (RAC/CP) is one of the units through which the Mediterranean Action Plan (MAP) develops a large part of its activities [see Note below]. Created as the *Centre for Cleaner Production Initiatives (CCPI)* by the Ministry of the Environment of the Autonomous Government of Catalonia in 1994, from 1996 onwards and through an Agreement between the Spanish and Catalan environmental authorities it undertakes, amongst its other functions, to be the unit of support for the MAP in matter related to the prevention of industrial pollution and cleaner production.

In Spain, the Agreement includes the possibility that the CCPI extend its field of activity to cover the whole of the country in activities to promote cleaner production and the reduction at source of waste and pollutant emissions, in collaboration with the competent environmental authorities in the Autonomous Community concerned in each case.

[2] The Mediterranean Action Plan (MAP) was adopted in 1975 by the states of the Mediterranean region and the EU, within the framework of the United Nations Environment Programme (UNEP), to foment the protection of the environment. Its activities are based on the Barcelona Convention, signed in 1976 and revised in 1995, and on 6 specific protocols.

[3] Kenneth Sadgrove says "*the company of the future will be environmentally proactive or it will not be*". I would agree with this statement.

[4] See Chapter 2.

This point of inflexion would correspond in time to the moment when this integration of the environmental management in the company came about and was given the same importance as the financial management, and the management of clients, purchases or production, with which it interacts. In a way, it is at this time that the Schumpeterian figure of the "innovative entrepreneur" makes its appearance. He who is capable of extracting gain, business or added value, in short, profit, from an apparently hostile or harmful situation.

But to do that, when we wish to explore the needs to be covered by the correct interaction between economic activities (particularly in industry) and the environment that will enable us to exploit the potential competitive advantages, we need to arm ourselves with instruments which enable companies to analyse the different options and make the right decisions, from an environmental and business point of view, following a technical and economic approach.

And amongst these tools, first those that enable us to explore the opportunities afforded by this more proactive relationship between the company and the environment and which starts, necessarily, with an analysis of which waste and emissions can be eliminated or reduced at source, within the process itself, before or instead of being treated to leave them in a condition that is acceptable for the receiving medium (air, water or soil).

In short, the challenge presented is more a business issue than an environmental one. A waste product, a discharge or an emission is something that the company, in some form or other (raw materials, labour, energy,...), has acquired or to which it has added value. It would seem logical, therefore, to analyse whether in the light of the evolution of technology or through the improvement and rationalisation of processes, that value can be recovered and in what feasibility conditions this may be done.

We are, therefore, putting forward a proposal that in no way breaks, but rather lends credit to, any principal of good business management and involves the saving and better management of the factors of production.

We said that "*waste or emissions are something the company has paid for*" and that it is worth studying the likelihood of recovery. However, it is also something the company will pay for when it is delivered to the receiving medium in the state the latter demands. It will pay in treatment, obligations, storage costs and, in the most extreme cases, fines or social or criminal liability. All the more reason to look into how to avoid or reduce those additional costs that add no value to the product or service.

In order to identify the potential advantages of a business policy that incorporates pollution prevention at source,[5] there is nothing better than a system of diagnosis and identification,

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[5] There are a number of proposals and programmes that differ essentially in name. Frequently, we are saying practically the same thing when we speak of "reduction at source", "prevention at source", "waste and emission minimisation", "cleaner production", 2P, 3R, 3P, "common sense initiative", "eco-efficiency", "design for the environment", ... What is more, each institution that launches a programme of this type, coins one of these phrase-programmes, elevating them to the category of differentiating element for their activities. Personally, I believe that this proliferation may lead to perceptions which are contrary to those one wishes to arouse amongst the business sector. Presenting an avalanche of proposals whose contents vary only slightly will not make the business world take up a more proactive position. A clear approach, constant and supported by evidence would possibly enjoy greater credibility. But we all want to be in the limelight for a moment... or an hour.

which is highly reliable, of the economic, technological and environmental advantages underlying the change proposed to companies.

It was in accordance with this approach that the CCPI began to propose to companies that they explore the opportunities hidden behind better environmental management.

Despite a clear idea of the sequence "diagnose-identify", we found that it was being applied incorrectly by the experts to whom the task was charged by the CCPI.

Overinfluenced by the concept of "auditing" (which is based on a principle of "compliance-non-compliance"), it was necessary to define a protocol which focused exclusively on prevention and reduction at source, dispensing with the degree of compliance, proximity or distance with regard to regulations.[6]

That was how the Minimisation Opportunities Environmental Diagnosis (MOED) was born. It was understood as an instrument that would enable the companies we came into contact with to assess the advisability of going ahead with a project, the aim of which was the reduction at source of pollutant waste and emissions. An instrument that is similar to rather than different from others already in existence, but which has proved extremely useful[7] to us at the CCPI and, furthermore, enables us to carry out a first approach to certifiable environmental management systems.

This last statement is particularly valid for small and middle-sized enterprises (the majority in any society) for whom a headlong jump into the demands of an ISO14000 or EMAS[8] certificate may prove traumatic. The knowledge of the opportunities for pollution reduction at source

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[6] Cleaner Production, or any similar proposal, has a bearing on a process and its environmental and technical efficiency. Premises that comply fully with the provisions of legislation, through *end-of-pipe* technology may house all kinds of inefficiencies in its productive processes. It is these that should be identified to be able to propose alternatives that show the advantages of proactive environmental management. For this reason, the degree of compliance is not a determining factor when applying a cleaner production programme.

[7] We all have the same sources and the CCPI (or the RAC/CP, if you prefer) was no exception. Amongst the works we used as a basis for drawing up what would later become the MOED, two must be mentioned which were perhaps ahead of their time, a little too advanced for what the Catalan industrial society was ready to admit, understand and put into practice. The first, the *Manual of Industrial Waste and Emissions Minimisation*, a work by the Cerdà Institute of Barcelona, was financed by various Spanish environmental authorities and published in 1992. The second was the *Media Manual*, published in 1995 by the Ministry of Industry and Energy. Both books, of outstanding quality, had approaches which, along with the lack of sensitivity and perception on the part of the business sector mentioned above, limited their usefulness:

- They were directed more at "problems" than "opportunities", which does not contribute to the development of a proactive approach.
- They were conceived as a self-diagnosis. This limited their usefulness for three reasons:
  - To be an efficient instrument, they imply a degree of awareness that did not exist and a discipline and a capacity for self-analysis lacking in many companies.
  - They require a complex organisational structure able to carry out this type of self-analysis.
  - Small and middle-sized enterprises, even supposing they were able to identify the opportunities, were unlikely to have the knowledge necessary to find the alternatives they could apply.

Reference could be made to many other publications, aimed more at providing information than being operative, but all with similar traits.

[8] Environmental Management and Audit System, a system of voluntary environmental management launched by the European Union.

comes with greater knowledge of the flow of materials and consumption of their activities and the correct allocation of associated costs, which will make it easier to incorporate the practices, and organisational changes brought about by a certified management system.

In a way, this reasoning can be summed up in the following sentence "*you cannot correctly manage what is unknown or badly gauged*". Strange as it may sound, this is a true reflection of the situation in many companies who are unaware or wrongly allocate environmental costs[9]: You cannot make a wise decision if you do not have all the facts.

This book aims to divulge, for use by professionals in the environment sector and businesses in general, the mechanism, methodology and, what is very often more important and enlightening, practical examples of what a MOED[10] is and of what it can be used to achieve.

It is structured in such a way as to enable it to be used in any company, regardless of the specific characteristics of each country. What does vary is the feasibility in the short term of the opportunities identified therein.[11]

I would not like to finish this prologue without acknowledging the institutions that have enabled it to be written and published,[12] within the framework of the Mediterranean Action Plan and the wish that it may prove useful for companies in the Mediterranean region in their evolution towards the production systems that will make this planet of ours more sustainable.

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[9] It should be pointed out as one of the factors that help or make difficult the correct allocation of environmental costs, the level at which environmental externalities are internalised, the existence and application of instruments of all types (legal, coercive, economic, fiscal,...) and the fact that raw materials (such as water and energy) are subsidised and do not reflect their real cost. It also depends on apparently external factors, such as level of development or culture, amongst many others but which, deep down, coincide and converge in what we have established as an objective and call Sustainable Development.

[10] Our website (http://www.cipn.es) contains information on the number of MOEDs directed by the CCPI and the sectors in which they are being used as a tool to identify opportunities for economic and environmental improvement.

[11] See Note 9

[12] The activities carried out by the CCPI as RAC/CP are financed by the Spanish Ministry of the Environment, as established in the collaboration Agreement mentioned in Note 1.

Glossary

This section includes the definitions of some of the terms used in this book.

Environmental audit / eco-audit. Management tool comprising a systematic documented periodic and objective assessment of an organisation's efficiency, its system of management and the means used to protect the environment. It gives management the control of any practice that may affect the environment and provides assessment of a company's environmental policies. (Ruling 1836/93 of the Council of Europe).

Environmental assessment. An overall preliminary analysis of the problems, effects and results, in environmental terms, of a centre's activities (Ruling 1836/93 of the Council of Europe).

Life-cycle analysis. Set of techniques combined together as an objective, systematic method for identifying, classifying and quantifying the pollutional load, environmental impact and the material and energy resources associated with a product, process or activity from conception to elimination.

BAT (Best Available Techniques). Set of techniques, activities, processes and working methods developed and tested on an industrial scale and designed to be applied in a specific industrial context in conditions that are economically viable for the company and put into practice to avoid or, where this is not possible, reduce emissions to a minimum.

BATNEEC (Best Available Techniques Not Entailing an Excessive Cost). The best techniques available, provided that they have been shown to be economically profitable once they have been applied in the corresponding industrial sector.

Good housekeeping practices. Set of correct operating practices for personnel, management and the control of industrial activities that encourage the minimisation of waste and emissions. In general, good housekeeping practices can be carried out at very low cost and investment is rapidly returned. Moreover, they are very effective. In many cases, the application of good housekeeping practices requires a change of attitude on the part of the entire personnel of a company, from machine operators to managers, which is achieved by informing them of the project to be undertaken and the proposed goals and, as these goals are attained, letting them participate in the results that have been achieved.

Changes of material. Substitution of materials that are less toxic or that can be used in smaller quantities, but that have the same use as raw materials and/or auxiliary products that have a significant effect on the environment.

Technology changes. Modifications in processes and equipment to reduce waste flows at source. These modifications can range from small changes that can be implemented at low cost and in a few days to process substitution that involves higher costs. Such changes may consist of: changes in the production process, substitution of equipment, sequencing and piping, automation, changes in the conditions of process operations (volumes, temperature, pressure, reside time, etc.), new technology (electronic data transmission, house automation, biotechnology, etc.).

Waste flows. Waste emissions in any physical state (gas, solid, liquid) or any receptor medium (water, air, soil).

Initial environmental diagnosis. See environmental assessment.

Minimisation opportunities environmental diagnosis. Assessment of the possibilities of minimising waste and emissions produced or generated by a specific industrial activity.

Emission. Expulsion into the atmosphere, water or soil of substances, vibrations, heat or noise directly or indirectly originating from specific or diffuse sources on premises. (Council Directive on Integrated Pollution Prevention and Control 96/61/EC, September 24th, 1996).

Minimisation. Reduction and recycling operations at source that bring about the reduction in the quantity and/or hazardousness of emissions generated in a production process and with a favourable environmental balance.

Product redesign. Readapting the properties and uses of manufactured products so that within a broad perspective their environmental impact is taken into consideration from the moment of manufacture until end disposal, at the same time as their resource requirements, for example, of energy, water and other specific materials are made as efficient as possible. This means a reduction in the quantity of inputs that the product requires in order to be manufactured and, at the same time, an increase in a product's useful life (for example, with parts that are reusable and can be dismantled, with a multifunctional capability, etc.)

Process redesign. Readapting the processes taking place in a business so that they are more efficient. This means making improvements in the saving of water, energy, materials, etc. by way of changes in the production strategy so that resources are not wasted, so that it becomes more efficient and so that waste flows are reduced.

Prevention. Set of measures aimed at avoiding the generation of waste flows or reducing them or the reduction of hazardous substance or pollutant they contain.

Cleaner production. The continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment. With regard to production processes, cleaner production includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes. With regard to products, the goal of the strategy is to reduce negative impacts during the life cycle of a product, from the raw materials extraction to its ultimate disposal. With regard to services, this includes incorporating environmental concerns into designing and delivering services. Cleaner production requires changing attitudes, responsible environmental management and evaluating technology options. (United Nations' Environment Programme).

Refuse. Waste or waste fractions of no value.

Source recycling. A valuation option that involves reusing a waste flow at the same production centre where it has been generated, either in the same process or in another.

Reduction at source. Any modification in a process, installation, procedure, product composition or raw material substitution that involves the reduction of waste flows being generated—in quantity and/or potential hazardousness—in the production process or in stages following production.

Waste. Any substance or object which is discarded or which the person in whose possession it is intends or is obliged to discard.

Hazardous waste. Waste with the properties of being explosive, comburent, easily inflammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, teratogenetic, mutagenic, ecotoxic; substances and preparations that give off toxic or very toxic gases when entering into contact with the air, water or an acid; substances or preparations that are likely after elimination to give rise to another substance in any medium, for example, a leachate with any of the aforementioned characteristics. (Directive 91/689/EC).

System of environment management and auditing. System that enables the voluntary participation of companies undertaking industrial activities to assess and improve the results of their industrial activities in relation to the environment and, at the same time, make the corresponding information public (Regulation 1836/93 of the Council of Europe).

System of environmental management. Any system implemented by a company to organise and control its environmental management.

By-product. Waste that can be used directly as raw material for another product or as a substitute for commercial products that can be recovered without the need for any treatment process.

End-of-pipe treatment. Treatment of waste flows downstream from the production process that has generated them, generally on the same industrial premises where the process takes place, to condition them prior to disposal.

Valuation. Procedure that enables the exploitation of resources contained in waste with no risk to human health and without the use of methods that are harmful to the environment.

1 Introduction

The purpose of this manual is to provide a practical guide for carrying out a **Minimisation opportunities environmental diagnosis (MOED).** It is a response to the needs of many businesses when incorporating criteria and decisions concerning environmental management and pollution prevention at source, as well as providing consultants with the necessary instrument for a specific work methodology and guidance when undertaking a MOED.

A MOED enables an assessment to be made of a company's business activities so that it can establish the potential opportunities available for preventing pollution in the premises under diagnosis, which in turn will lead to improvements in business competitiveness and the environmental relationship that the business activity has with its surroundings.

The book is aimed mainly at experts who work in the environment sector and intend to carry out the environmental diagnosis of business activities on the basis of **Cleaner production,** or, in other words, by giving priority to pollution prevention and reduction at source in a way that has developed through experience gained at the Centre for Cleaner Production Initiatives since MOEDs began to be undertaken by companies in 1996.[13]

[13] The writing of this book was based on a study by AUMA., Consultores en Medio Ambiente y Energía, S.L. that summarises the methodology used. The final draft was written by the technical staff at the CCPI: Marina Centelles, Belén Gállego, Iñaki Gili, Raül Luna, Esther Monfà, Beatriz Parrilla, Rosa M. Sánchez and Olga Villacañas.

2 Cleaner production

Cleaner production[14] is an option for environmental management that is available to business activities. It includes pollution prevention at source and the minimisation of waste flows,[15] which are alternatives that seek to avoid pollution generation as a preferable strategy to end-of-pipe treatment.

Cleaner production follows this strategy and applies it to processes and products.

With regard to processes, cleaner production includes the conservation of raw materials, water and energy, the elimination or the reduction of toxic raw materials or the quantity and toxicity of superfluous waste flows.[16]

With regard to products, the aim of the strategy is to reduce all impact during the product's life cycle, from the extraction of the raw materials to end waste.

2.1. From end-of-pipe treatment to cleaner production

The paradox caused by the limited availability of resources and the need for growth and progress in society (to which industrial activity responds decisively by furnishing it with goods and services) requires the reappraisal of processes and mechanisms of management in business. Too often, industrial activities accompany the provision of goods and services with the undesired generation of refuse material and impacts on the environment, the quantity and hazardousness of which businesses are unaware of.

Historically speaking, there are three stages that characterise the attitudes and responsibilities of industry towards the environment.

[14] The expression *clean production* has been used in an extreme way as an idealised end stage. We prefer the expression *cleaner production* because it illustrates a more dynamic characteristic that in business denotes a trend.

[15] In Catalonia, minimisation was initially orientated especially towards reducing the volume and toxicity of the most hazardous waste, but the concept subsequently broadened to cover all waste flows.

[16] Waste flows that can be realistically avoided or reintroduced into the productive process.

1. Initially, there was a long period of industrial production that put any environmental consideration to one side. This context changed when new concerns appeared involving the protection of the environment together with the awareness of the limitations of the planet's resources and the effects derived from the impact produced by industrial activities, amongst others, on the environment and man's quality of life. At the same time, environmental legislation[17] that was related with these concerns also appeared, which gave rise to a new scenario where business has had to respond to new demands and consider the old system of production, which was lacking in environmental criteria, as being a thing of the past and obsolete.

2. In response to the new demands for environmental protection and the incipient environmental legislation, businesses began to anticipate the internalisation of environmental costs brought about by their industrial activity by initiating environmental management with correction criteria aimed at the end-of-pipe treatment of waste flows. The first steps were aimed at constructing numerous equipment and premises (treatment plants, incinerators, stabilisation and disposal premises, etc.), with waste and industrial emission treatment systems that often favoured the transfer of pollutants from one physical medium to another, and are therefore not so effective from the point of view of the integrated reduction of pollution. These measures involve an economic expense; they don't “add any value”; they only act once pollution has been generated; and they have to be repeatedly put into practice because they do not treat the source of the pollution.

3. At the present time, a course is being set that will bring about a veritable change in the way the problem of pollution is approached and managed, as is the generation and treatment of waste flows in business activities that goes beyond the mere prescriptive nature of legislation by offering new opportunities for optimisation and saving in business. Although we obviously cannot consider installations that are merely corrective, and which are complementary, as being a thing of the past, unnecessary or out of date, the trend is towards cleaner production. Prevention is a working hypothesis and the first option that needs to be studied, both economically and environmentally speaking, and is much less expensive than correction.

This order of priorities when approaching environmental management in business should follow the sequence appearing in the following diagram *(Figure 1).*

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[17] According to *Waste Minimisation. Environmental Quality with Economic Benefits* (April 1990. EPA / 530 - SW-90-044), a publication by the United States Environmental Protection Agency, it wasn't until the mid 1970s that the problems associated with toxic and hazardous waste (a name that varies according to local legislation), parallel to which, at the same time, the Resource Conservation and Recovery Act began to develop extensive legislation on the subject. In relation to this, the *Toxic Release Inventor*y was developed in the USA, which were emission inventories of over three hundred controlled toxic substances.

It must be said that despite the new trends towards cleaner production, which are already firmly established as an idea, there are still businesses that have to get over this initial hump, along with a series of basic obstacles because their imperatives have more to do with the classical concepts of competitiveness and productivity, the level of sales, etc., than with impact minimisation and waste flows that they generate. When it comes to guiding programmes and implementing cleaner production policies in business activities, the obstacles can be summarised as follows:

I. Environmental management is considered to be an economic burden and not an opportunity to optimise processes and reduce costs.

II. Many businesses have no organised or structured information about their environmental situation, either from an in-house or an external point of view.

III. Established systems, tradition, routine, day to day work and production needs all add up to a lack of information in many businesses on prevention and pollution reduction, on the technology and techniques that make these possible, and the competitive advantages that they generate.

IV. There are still few businesses with specialised, in-house experts to deal with the environmental questions generated by their production and organisational processes.

V. The main aim to be considered nearly always tends to be the achievement of emission or disposal thresholds laid down by legislation and to not go any further, which is precisely where one finds the true marginal benefit of environmental management.

VI. For many environmental experts and consultants, it is easier to resort to corrective end-of-pipe solutions than channel actions to prevent and reduce pollution at source for this means getting deeply involved with production processes.

VII. The integral costs of environmental management (recovery, storage, transportation, disposal, taxes, etc.) are generally unknown and incorrectly assigned to the product as a general expense.

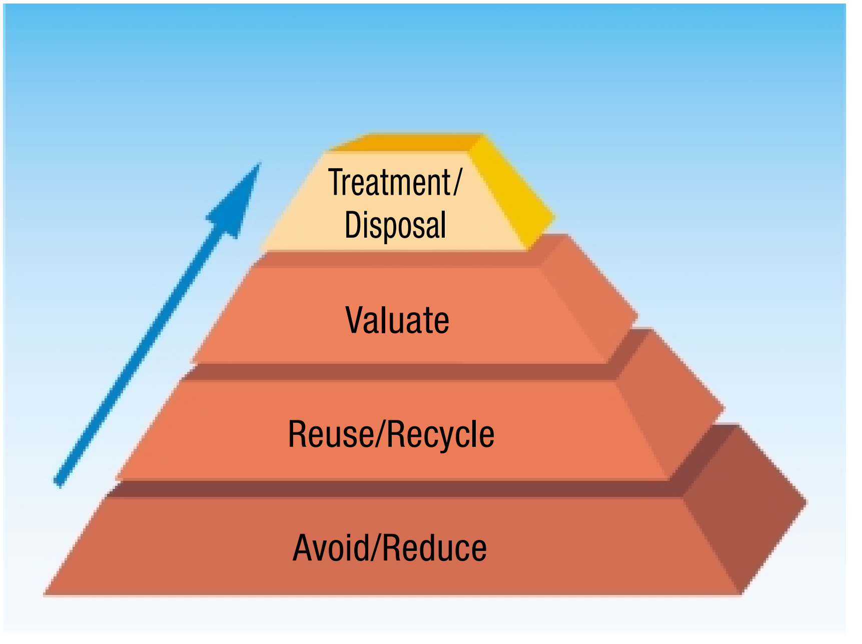
Cleaner production offers a series of advantages when compared to end-of-pipe pollution treatment that make it preferable as a strategy for environmental management in business, although we should not forget that end-of-pipe treatments, as corrective measures, are a complement.

Cleaner production as an integral management strategy

Cleaner production is a business management strategy that goes beyond any specific goals that may arise on occasion and entails a policy that takes all of the productive process of a business into account. End treatment, on the other hand, does not take the whole productive process into account and only deals with specific effects without confronting the origin. It also adopts a position that just tags along behind any problem that arises.

Figure 1

PRIORITIES OF ENVIRONMENTAL POLICY



Cleaner production as a source of opportunities

Cleaner production optimises processes taking place in the company, it enhances the adaptation to new trends towards process efficiency and facilitates the company's growth and competitiveness through improvements to its operating conditions. End-of-pipe treatment, on the contrary, offers no new opportunities to the business, as it only responds to mitigating the waste flows that are generated. Cleaner production can be said to promote the *software*, and provides an analysis, opportunities and a more efficient way of operating within the business, whereas end-of-pipe treatment is based only on the *hardware,* on actions with no added value, such as investment in equipment and premises, or external treatment processes.

Cleaner production as an adaptable strategy

As a strategy incorporated within the production process as a whole, cleaner production utomatically responds to the variations that this process may produce (increase in productivity, increase in the use of certain materials, etc.), and can be applied to a specific process or all of the processes in a business, to different stages of a process or it can be started in stages according to the needs and possibilities of the company.

End-of-pipe treatment is less adaptable as it is only conceived as a supplementary phase of the production process and can therefore not respond so easily to changes occurring within that process.

Cleaner production and economic profit

Through the application of viable cleaner production measures, savings are made in the cost of waste flow treatment while the fostering of more efficient measures leads to savings in the consumption of water, energy, raw materials, etc. At the same time, the optimisation of production processes brought about by cleaner production can lead to an increase in a business' productivity[18] due, for example, to time-saving which can be reinvested in the same process, or, with cleaner technology, to production being increased at the same time. End-of-pipe treatment does not anticipate any saving in costs for the business while, on the contrary, **it does involve an additional cost that is constant and which grows as business production increases and as the result of any new regulation that may appear.**

Cleaner production and the environmental benefits

Cleaner production is a more positive option for the environment in that it prevents the generation of pollution and brings about a more efficient use of resources. End-of-pipe treatment is also an option that reduces the pressure of contamination on the receiving medium, although it acts only after this has been generated and does not bring about the more efficient use of water, energy, raw materials, etc.

Cleaner production as an integral policy of involvement

Cleaner production improves and optimises the working structure and level of technical development in a business. Moreover, it is a strategy that is adopted by the entire workforce of a company, from machine operators to the managing director, and involves a prior learning and awareness process that is reflected in better environmental and production practices.

End-of-pipe treatment involves the conscious action of the company director who proposes the measure and of the specialist who implements it but it does not promote responsible actions that include the involvement or benefits that derive from the entire workforce.

[18] The combination of a more efficient use of resources together with an added increase in productivity is called eco-efficiency.

Cleaner production and the corporate image

Any strategy that incorporates environmental criteria is beneficial to the corporate image. Cleaner production and the treatment of waste flows comply with this requirement, although present trends show that prevention is better than correction, in both environmental and economic terms. Pollution prevention is thus the best option for the corporate image of a business.

The following diagram clearly sets out the actions needed to promote cleaner production in a business activity. *(Figure 2)*

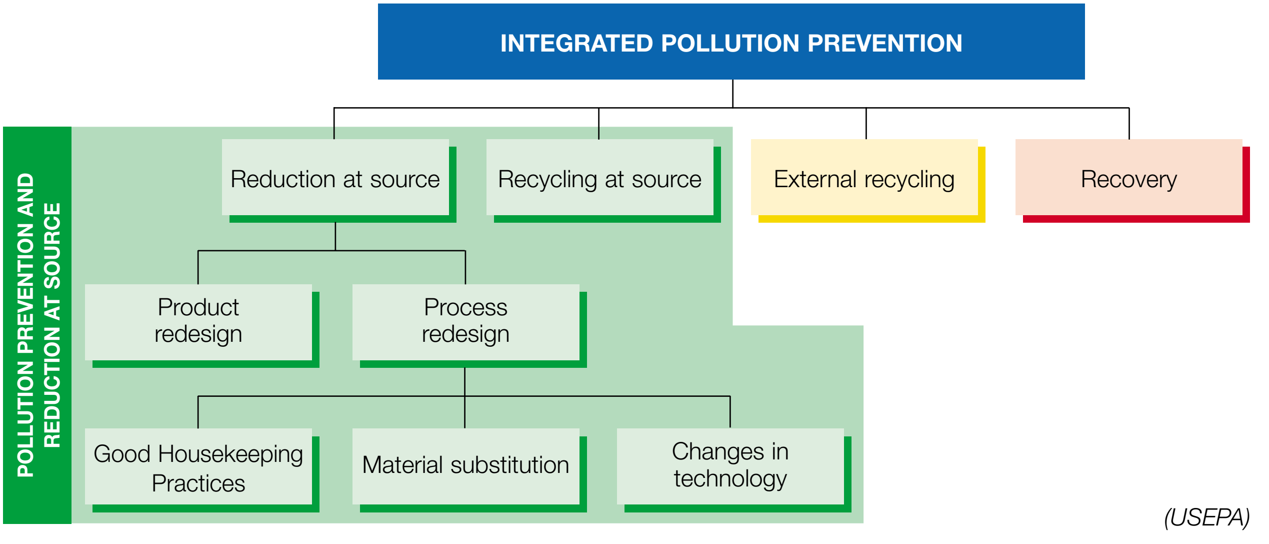
Once it has been accepted in principle that pollution prevention at source has advantages for the production process, it is necessary to move on from theory to practice. How can the opportunities to reduce pollution at source be detected in each specific case? And, something that is fundamental for businesses, how does one distinguish the options (of prevention or treatment) that are more viable and recommendable?

One obviously cannot correctly manage something that is unknown and/or insufficiently identified or measured, in short, undiagnosed.

A diagnostic tool is thus necessary for enabling a business that is designing its environmental policy to decide which options are open to it and to what degree. The MOED is one of these tools.

Figure 2

POLLUTION PREVENTION AND REDUCTION AT SOURCE



(USEPA)

3 MOED: definition, characteristics and advantages

A MOED is the assessment of an industrial activity to detect potential opportunities for preventing and reducing pollution at source, and for providing the business with sufficient data for it to orientate its policy towards cleaner practices and technology that are technically and economically viable.

A MOED is a tool available to businesses involving a limited economic outlay and an average execution time of 4 weeks, in the case of small businesses, and 15 weeks, in the case of larger companies.[19]

A MOED is an assessment carried out by experts that are familiar with the industrial activity in question and how it interrelates with the environment. The aim is to provide the business with a document containing sufficient technical and economic information concerning the existing opportunities so that it can assess the convenience of actions aimed at preventing and reducing pollution at source.

A MOED can diagnose an industrial premises in its entirety or just a part of it (a particular unit, a specific production line, etc.).

It should remain very clear that a MOED **is not an environmental audit,** because the final objectives are quite different. A MOED specifically analyses production processes and waste flows with the purpose of identifying the opportunities for environmental improvement connected with the processes, whereas the environmental audit undertakes a more general study to establish to what degree it complies with legislation, which is not the purpose of the MOED. The MOED is a flexible tool with a defined methodology and specific aims that provides the company with a comprehensible document that serves as a decision-making factor with regard to the planning of actions that prevent pollution.

Its characteristics are:

- Flexibility when being carried out.
- Little economic outlay.

[19] The period can obviously vary depending on the team, the work schedule, and the amount of documentary recording, the location of the premises and the collaboration of the company itself.

- The compilation and preparation of relevant environmental information.
- The critical analysis of processes and the identification of opportunities.
- The preparation and bringing together of specific alternatives.
- Evaluation of attainable environmental improvement, the associated costs and savings and the technical and economic feasibility[20] of the alternatives, given the present situation and e. o. p. options.

3.1. Who could be interested in a MOED?

While a general answer to this would be that “a MOED is of interest to all industrial businesses” in terms of the strategic decision that it represents, a MOED is more specifically speaking of special interest to the following groups:

- Companies that, as a result of their industrial processes, generate important quantities of waste flow or that handle a large volume of raw materials.
- Companies that produce special waste (toxic and/or hazardous),[21] regardless of the volume that they generate.
- Companies that do not know what their waste flow is (focal point of generation, mass quantities or volume involved, final destination or cost added to the final product of waste flow).

In fact, a kind of proportional rule could be established according to which a MOED is especially appropriate to any company whose waste flow can be described by any of the following concepts: **unknown, quantity, hazardous, or unknown costs.** *(Figure 3)*

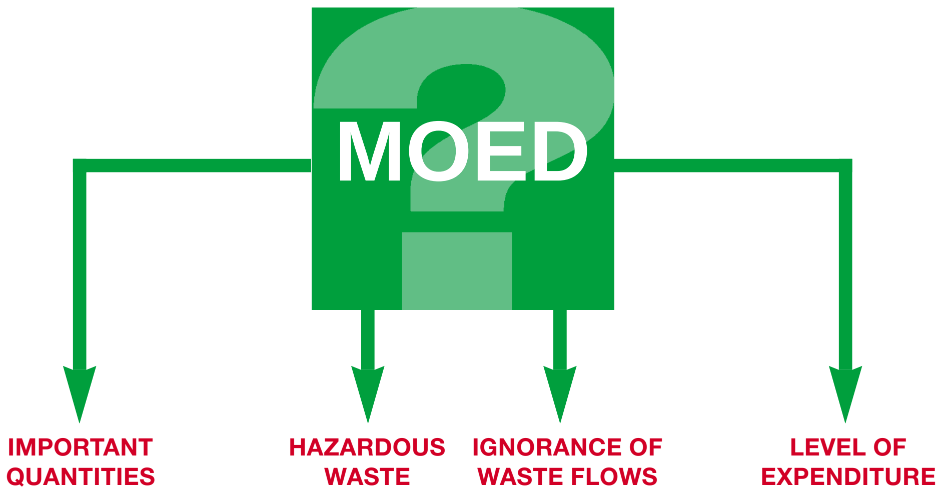
MOEDs have also proved to be very useful in the case of companies in need of some kind of administrative regularisation. Generally speaking, specialists from administrative authorities (local council authorities, bodies that are responsible for waste and wastewater, etc.) see MOEDs in a favourable light and consider their being carried out as a positives step because it is a sign that companies are assuming the policy of pollution prevention and reduction at source.

[20] See appendix 2: analysis of the technical and economic feasibility.

[21] As an example, in Spain RD 952/1997, June 20th, disposes that producers of toxic and/or hazardous waste must prepare and submit a minimisation study per unit produced of this waste to the corresponding Autonomous Community within the period of four years after the Decree comes into force, and subsequently every four years, and they must also undertake to reduce the production of this waste within the limits of their possibilities.

Figure 3

WHO WOULD BE INTERESTED IN A MOED?



What is required of the company before starting a MOED

The carrying out of a MOED in industrial premises questions routine procedures and technology. For this reason, a positive, collaborative attitude is necessary for it to be appropriately developed and it is the company itself that will benefit most from this. Such an attitude can be summarised as being:

1. Well inclined, with the management of the company in total agreement. This means that the carrying out of the MOED needs to be integrated within the strategic policy of the company.
2. A person with the sufficient know-how and level of responsibility is designated to act as a spokesperson and in-house representative to help in the MOED and its monitoring, and thus facilitate the work of the consultant and to synergistically improve the results of the diagnosis itself.
3. It needs to present the goals being pursued with the MOED to the company workforce, together with the person that will be doing it. The aim of this is to avoid the mistaken sensation that the workforce may have of being under examination and that they will be singled out as being responsible for the economic and environmental inefficiencies occurring in the production process.
4. Willingness to establish a close collaboration with the expert who is carrying it out, to provide him/her with the appropriate documentation and to willing act in such a way that someone who is from outside of the company can analyse it.

3.2. The economic and strategic advantages in carrying out a MOED

The courses that a business can follow in its strategic policy are diverse (growth, quality, innovation, customer satisfaction, etc.). However, due to the fact that companies incorporating the environmental variable into their strategic policy will be those that are best prepared for the future, they not only have to take these considerations (measured according to economic profitability) into account when making decisions concerning investment but also the environmental impact generated by the activity. For this reason, both the environmental and economic benefits of every decision have to be weighed up.

The carrying out of a MOED represents the first milestone in a company's *pollution prevention and reduction programme at source*, and it is a strategic decision that involves a proactive environmental policy, which means respecting the environment in the course of its activities, and making use of a whole series of advantages that derive from this.

This business strategy incorporates a dynamic factor of change and continual improvement that transcends the fragile, static viewpoint of environmental policies based on End-of-pipe treatment.

This minimisation of waste flows makes it the company itself that can benefit most directly and is the point where we believe it can be ultimately understood that respecting the environment does not necessarily represent any added cost for the business.

The ultimate goal of the MOED is to propose different opportunities to the company that are technically and economically viable for **reducing the environmental impact of its activities.** As is explained further on in the manual, there are examples of an important reduction in the environmental load with an immediate return on investment (the usual case when implementing good housekeeping practices) and others with time limits comparable with the best business decision.

This economic data, which continues to surprise more than one entrepreneur, are the result of the reduction in costs generated by the new production process compared to the present one, for example, in the cost of treatment or final disposal of the input materials, public services, insurance, or poor quality of the product.

The carrying out of a MOED and the knowledge, objectively speaking, of the opportunities for improving the production process is sometimes the definitive boost that an entrepreneur needs to implement new technology and increase productivity in this way.

Parallel to this, the company also benefits from a series of advantages that are difficult to evaluate but which are just as important. These are the so-called intangible benefits, such as the enhanced corporate image of the company, which is something that improves the politics of communication and relationships with government authorities, suppliers, clients and neighbours; improvements in the quality of the product and the likelihood of introducing it into new markets; an increase in personnel satisfaction and level of training; a reduction in the risk of accidents and penalties; the anticipation of new scenarios; all of which will increase competitiveness compared to the rest of the sector; and afford greater adaptability concerning changes in regulations and legal requirements, etc.

In the international sphere, it must be said that the majority of countries are clearly advocating pollution prevention and reduction at source as being the primary option instead of end-of-process treatment. It is for this reason, and for fear of falling behind or going against the flow, that high priority be given to the incorporation of this strategic business decision, a process which could well start with a MOED.

3.3. Who should carry out the MOED?

MOEDs are conceived to be made by experts who are familiar with the industrial activities and processes to be analysed, new technology and the alternatives that exist. They must also give consideration to the relevant environmental aspects and be familiar with the characteristics and parameters of the waste flows that are being put forward for minimisation.

This idea, which is far removed from other approaches (such as all of the existing *self-assessment* series), is justifiable for a series of reasons, which include the following:

1. Diagnosis makes evident a series of malfunctions that are often the result of routine practices or activities. In an organisational structure, it is not easy to point out these malfunctions internally without the head of department, section or unit where they are identified feeling personally criticised.
2. The aim of the MOED (as opposed to other instruments that focus on how much a particular regulation is complied with) is to put forward a range of alternatives. This means being familiar in each case with the latest technology. It is much easier for the true expert to acquire this knowledge than the majority of businesses, especially SMEs.
3. Solutions and proposals often come out of other solutions that are applied in sectors that are in theory quite separate from the company being diagnosed. This fact reaffirms what is explained in the previous point.
4. There is often not enough time nor the methodology to carry out a diagnosis in the way that is described here, especially in the case of SMEs.

This does not detract from the fact that the preparation of the external team, together with the necessary co-ordination and experience, needs to be complemented with the support and collaboration of the in-house personnel assigned by the company to be in charge, because these are the people with specific knowledge of the process. Agreement between them is the key to the satisfactory development of the diagnosis and will lead to it being much more practical.

Whoever carries out the MOED will also have to ask for and obtain information from the stores' location personnel and production and maintenance operators who are the people that have the information and knowledge that is undoubtedly invaluable from the environmental point of view.

For a MOED to be successful, an active relationship must be established between:

I. The business receiving the MOED.
II. The team of consultants carrying out the MOED.[22]

The choice of expert

Unfortunately, it has to be said that “everybody has a go with the environment”, and the short history of the relationship between business and the environment is full of examples where companies have entrusted their environmental problems to people who have not been in a position to understand or, much less, resolve them,[23] and some results have been both deplorable and inefficient.

When we talk of diagnosing, it is obviously essential that the consultant be familiar with and know the MOED methodology and how it works, as well as the sector, equipment and industrial processes of the company.[24]

When pollution reduction at source forms part of the environmental policy priorities of environmental administration, it is recommended that any type of voluntary action being carried out, such as the MOED, be supported by a **data base of experts** created to gather information that helps companies choose with the minimum margin of error.[25]

This information base,[26] which should be periodically updated, should include verified information on:

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[22] Where the environmental administration collaborates in the MOED, as is the case in Catalonia, its task is to supervise the diagnosis by monitoring the methodology and the quality of the final report.

[23] Mention should be made of some of these where suppliers were offering "miracle" and "all-round" technology.

[24] Cases have been detected where this kind of diagnosis has been carried out by students or people with qualifications but lacking in the necessary experience with subsequent poor results. This is an unhealthy practice and the means for preventing this should be established.

[25] Some environmental authorities or even semi-public and private institution have opted to offer and carry out this diagnosis service directly to companies. While this option may be valid in a society where there is a lack of technical specialists who are familiar with this approach to environmental management, this cannot be justified where there is a more extensive provision of environmental services. These actions, which are carried out directly by government authorities or specific institutions, may border on unfair competition from a position of privilege. Another thing is to establish systems that guarantee as far as possible the correct choice of expert by the company and the quality of work that is presented.

We are convinced that the model used in Catalonia is a good one. The example of certain apparently similar initiatives financed by a group or «club» of consultants or above all, suppliers of technology, only serves to "disguise" a lobbyist practice and convert the companies that approach a supposedly neutral body into captive clients.

[26] In Catalonia, the Centre for Cleaner Production Initiatives has maintained an active data base of experts and suppliers of environmental goods and services since 1995, where companies that duly fill out a form where they provide information on the company's resources (human, logistical, economic, etc.) can be added voluntarily, and the most important studies and work carried out in relation with pollution prevention. This catalogue, which is not a form of approval, aims to help companies wishing to carry out a diagnosis and the Centre itself when proposing the most suitable consultancy firms to carry out the MOED.

- the sectors in which each expert has worked professionally.
- the different jobs carried out in terms of pollution prevention and reduction at source.
- the results of minimisation achieved in the different companies.
- knowledge of the sector or process being diagnosed.

4 Carrying out the MOED

Once the necessary framework and basic concepts have been defined, it is necessary to enter fully into the structure and methodology used in undertaking the MOED.

Before beginning, however, here again are a series of points that the expert in charge of doing the MOED should never lose sight of:

The MOED is not an environmental audit:

The use of an erroneous strategy —which is often the case with some specialists— must be avoided during the course of the diagnosis. This consists of reiterating the inherent problems, the threats and consequences of not complying with legislation.

It should be made clear that the main aim is to identify the alternatives for pollution prevention and reduction at source and bring about an improvement in the company's environmental management through pollution prevention.

The MOED needs to be a flexible tool:

This second aspect refers exclusively to the teams of experts. One needs to avoid handing out questionnaires or checklists that are excessively long or disproportionate in terms of content and centre on the goals of the study.

The MOED is not a project in detail:

This doesn't mean that one should be a generalist. On the contrary, specific processes and sub-processes have to be studied and information provided that is both technically and economically appropriate for the company to subsequently have a detailed project made for the alternatives that are chosen.

The MOED is made by the expert:

The consultant should do the actual job of filling out the questionnaire.

Although different self-diagnosis manuals for companies have been written, experience shows that they get used very little, either because of organisational and structural problems, or because the pressure of day-to-day work imposes other priorities. Likewise, it is possible that the expert's independence from hierarchical and functional associations enables him/her to benefit from the synergy that occurs with the company.

4.1. The procedure involved in carrying out a MOED

THE WORK OF THE CONSULTANCY FIRM	
1. Initial visit and meetings	6. Information processing
2. Definition of the basic guidelines	7. Assessment of minimisation opportunities
3. Presentation of the work proposal	8. Study of the specific options
4. Acceptance of the MOED	9. Drawing up and presentation of the final document
5. Working visits: staff interviews, worksheets, checklists	

4.1.1. *Initial visit and meeting*

Before starting the diagnosis, it is necessary for the expert to visit the company and make initial contact. This way, the aims and scope of the work can be clearly defined.

4.1.2. *Definition of the basic guidelines*

The first stage in the planning of a MOED requires the following aspects, at the very least, to be well defined:

- The scope of the study
- Significant areas and processes
- The key questions to be concentrated on
- Aspects that can be excluded
- The list of people to be interviewed and their positions
- The data collection method (in-house and external)

4.1.3. *Presentation of the work proposal*

The following need to be explained to the company and specified:

- The anticipated results
- The implementation programme
- The degree of participation expected from the company
- The expense budget, with clear indication of the aspects not included in the MOED (legalisation of premises, analytical techniques, etc.).

It is also important to inform the entire workforce of the objectives and the anticipated implementation programme.

4.1.4. *Acceptance of the MOED*

Once the company has formally accepted the proposal for the service, the implementation of the MOED is put into operation.

4.1.5. *Working visits*

The aim of these visits is to collect information on the business which is normally disperse, underestimated or unknown by the company itself.

The exact number of visits to be made varies according to the company's size and/or complexity, but between two and four visits are usually sufficient.

A visit consists of a check being made of the processes, equipment and premises, and work procedure. The work tools consist of:

- **Interviews with personnel:** these are carried out in all areas (foremen, operators, etc.) and work shifts, because work procedures may vary a lot from one person to another, especially when they are not written out. These interviews are sometimes a way of gathering ideas for improvements from the employees themselves.
- **Data collection:** In order to make the monitoring of the industrial activity that is being diagnosed easier, and for this to be orderly and structured, the expert will previously need to have prepared his/her data collection system to be able to start the MOED. At the very least, the following data need to be obtained beforehand:

GENERAL DESCRIPTION OF THE COMPANY
Company name
Address or head office
Telephone, fax, e-mail
Lines of production
Main activity
Sector
Total number of workers
Turnover
Type of company (small, medium, large)
Company’s environmental policy, programmes, resources allocated

DESCRIPTION OF THE INDUSTRIAL PREMISES
Address
Telephone, fax, e-mail
Number of workers
Product manufactured and amounts
Description of manufacturing processes
Brief description of other areas of interest (warehouse, services, etc.)
Main raw materials and auxiliary products (amount consumed)

For each of the raw materials used in each process:

INFORMATION ON THE PROCESS: RAW AND AUXILIARY MATERIALS
Name of raw or auxiliary material
Source/supplier
Annual consumption
Consumption per unit produced
Purchase price
Annual total cost
Components or properties with a significant effect on the environment[1]
Method of supply[2]
Method of storage[3]
Method of transfer[4]
Best before date
Possible return to supplier of empty packaging
Possible return to supplier of material past its best before date

[1] Heavy metals, solvents, toxicity, volatility, special waste, etc.
[2] Piping, tanker, bags, drums, etc.
[3] Cisterns, pallets, outside tanks, underground tanks, silos, etc.
[4] Pump, gravity, pneumatic transport, conveyor belt , etc.

For each product manufactured:

INFORMATION ON THE PROCESS: END PRODUCT
Name of product manufactured
Product type or family
Annual production
Average selling price
Components with a significant effect on the environment
Method of storage
Packaging type for distribution
% of product not complying to specifications
% of product not complying to specifications which is reprocessed
% of product returned by client
Possibility of recycling product postconsumption
Return of packaging by client

For each waste flow:

Identification of waste flow
Source/Cause
Amount generated annually
Components or properties with a significant effect on the environment
Has any action been taken to reduce or recycle at source?
Type of management or treatment
Cost of in-house treatment
Cost of external management

This data will obviously not be enough for the expert to define the processes and sub-processes. The data is given with the fundamental idea of guiding the expert so that he/she continues to add points to be studied. Moreover, it would be impossible to give here an appropriate list for all the different types of company; each company is totally unique, even within its own sector. The expert must thus broaden and develop his/her work notes accordingly.[27]

[27] In Catalonia, the CCPI requests that all worksheets generated during visits to the industrial premises are enclosed with the end report.

It is highly advisable that the expert makes his/her process diagrams during the visits, because they will be very useful when making a diagramatic study.

From the expert's point of view, different methodologies can be used for collecting data. In some cases, a methodology based on environmental vectors (water, air pollution, etc.) can be used, while in others, the emphasis can be on processes. The choice of the most suitable methodology is made according to the complexity of the processes or the characteristics of the company. Our opinion is that the best orientation is in terms of the actual processes that exist.

As far as methodology is concerned, it can thus be seen that, during the initial phases, the carrying out of a MOED does not differ very much from that of a conventional environmental audit. In terms of the team of experts, once the work group has been established and the preliminary co-ordinating meetings held to analyse the basic guidelines for action, it is a question of working in accordance with a structured methodology.

4.1.6. *Information processing*

Next, the information in **black boxes**[28] is processed. The documents are analysed, missing data are requested, these are repeatedly checked and one studies the *waste flows* in detail until what they are and where they are generated has been established. To sum up, it is basically a question of classifying, putting into order, inferring and assessing the most significant losses in the processes and activities by analysing the material balances. *(Figure 4)*

4.1.7. *Assessment of minimisation opportunities*

For each waste flow, a study must be made of:

- The quantity generated.
- The process where it is generated.
- The environmental impact.
- Expenditure, given the existing production scenario of the activity.

This will identify the specific options for improvement.

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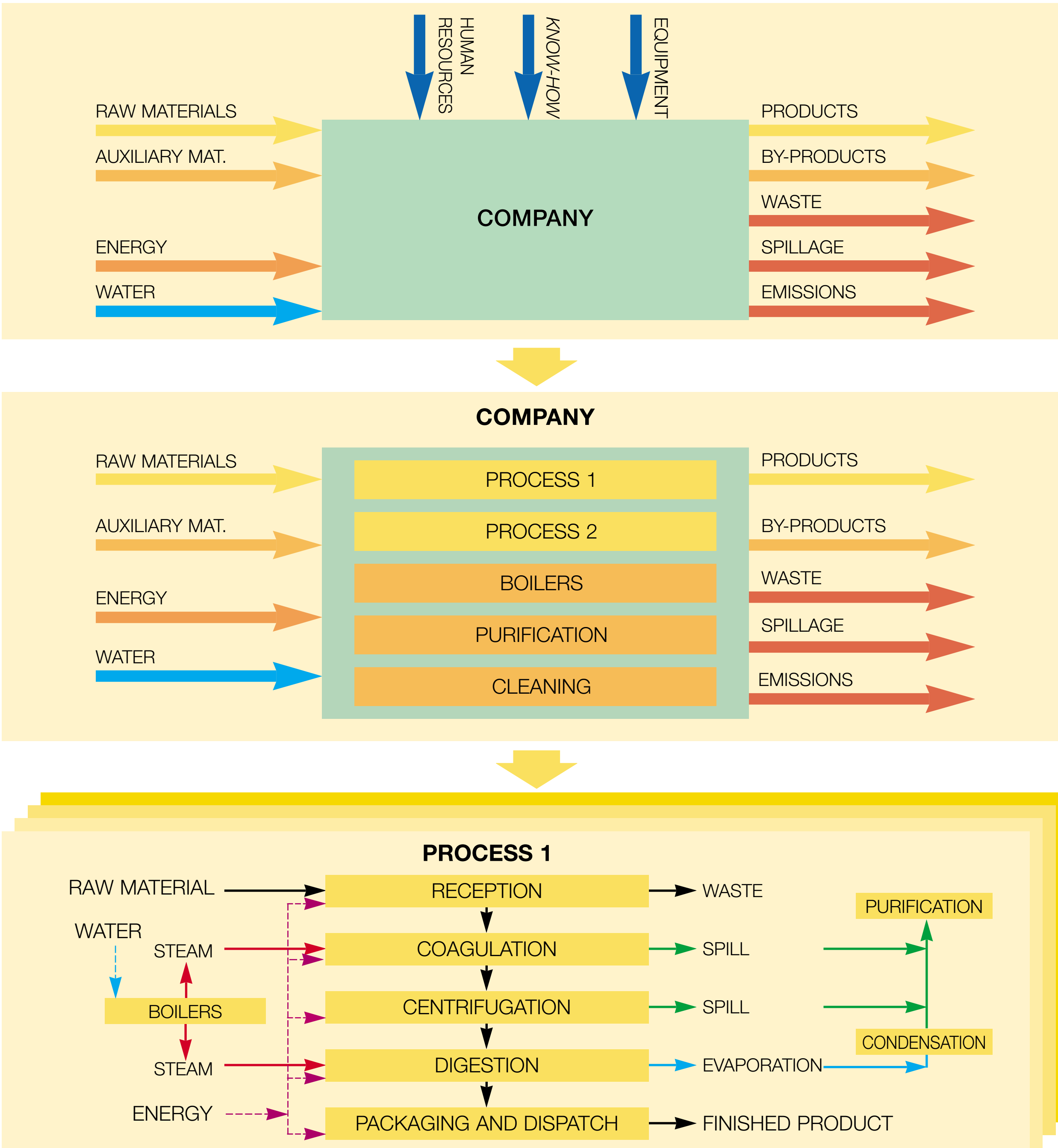
[28] The **black box** treatment is a kind of balance *(input-output*) of raw materials, energy and waste flows which works like a *zoom* on the initial overall assessment and which makes an in-depth study of the processes and their details, through the use of flow charts, until it reaches the required level for identifying the object waste flow. It is interesting to point out that this analysis occurs in two ways. Normally it starts out with a waste flow (*output*) until this reaches a process, or a raw material, which then follows the process flow until it becomes waste, and so on as many times as is needed.

Figure 4

BLACK BOX DIAGNOSIS PROCEDURE



4.1.8. *Study of the specific options*

The MOED includes a detailed description of the different alternatives proposed, it justifies the reasons why they are recommended, it assesses their environmental benefit and it analyses the technical and economic feasibility.

The order of priority in the minimisation proposals is established according to their minimising effect:

1. Options for reduction at source
   - Product redesign
   - Process redesign: change of materials, alternative processes, new equipment, good housekeeping practices
2. Source recycling options

In order to analyse the feasibility of each of the proposed alternatives and in a logical order, the technical feasibility is analysed first and then, according to the determining factors, the economic feasibility.[29]

The object of the technical feasibility analysis is to check the possibility of implementing the alternative being analysed in the business and whether there is any type of determining factor that cannot easily be overcome.

If the results of this analysis are positive, the economic feasibility analysis is carried out, which gives the company the necessary data concerning the economic implications of implementing the particular alternative. Estimated net savings due to the implementation of the proposed alternatives in relation to the present process are specified, the payback period is calculated and, when necessary, the profitability of the project is evaluated by calculating the net current value and the internal rate of return. This estimate can only be made if a sufficient data is available on the proposed alternatives, such as investment, operating expenses, the cost of alternative products, etc. For this reason, information and data will have to be obtained during the course of the MOED work on the buying and selling price of products, industrial operating expenditure, expenditure on environmental management, etc.

As MOEDs involve research of the technological possibilities for offering alternative proposals for modifying and improving the affected operations and processes, a good knowledge of the most suitable technology and of the suppliers is essential.

4.1.9. *Preparation and presentation of the final documents*

A first draft is presented which the company[30] has to accept and check whether the data are correct or not. Once this has been affirmatively checked, the final document is presented and handed over. This is the moment when there is a meeting with the company to comment on the results obtained and when a programme is suggested for implementing the alternatives that have been identified. *(Figure 5)*

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[29] See appendix 2: analysis of the technical and economic feasibility.

[30] In the case of MOEDs directed by the CCPI, this draft and the following ones, up to the final document, are revised by a CCPI technician. He monitors the process from start to finish to ensure the quality of the work and the usefulness of the proposals and opportunites identified.

Figure 5

PRACTICAL STAGES FOR CARRYING OUT THE MOED

STAGES	ADVANTAGES
PRIOR MEETING MOTIVATIONS	Incorporation of new environmental concepts
AGREEMENT TO DO IT	Definition of objectives Selection of consulting team
INITIAL CHECK OF THE INFORMATION	Collection of dispersed information or information unknown to the company
DATA INTERPRETATION	Description of the process Identification of the generating sources Loss assessment Graphic representation of results
ASSESSMENT OF THE OPPORTUNITIES	Impact and cost analyses Contribution of new elements by the expert
IDENTIFICATION OF THE REAL OPTIONS	Search for technical solutions with suppliers, costs, pay-back period advantages and disadvantages
PRESENTATION END DOCUMENT	Presentation and analysis with the company

5 Structure of the document

The ultimate aim of the MOED is to detect possible technical and organisational alternatives for reduction at source and recycling. These should appear in the **final document,** adapted according to each business, that should at least incorporate the points indicated in the following table:

5.1. Introduction and background
5.2. General description of the company
5.3. Description of the industrial premises
5.4. Description of the activities, manufacturing processes and areas under diagnosis
5.5. Description of waste flows generated
5.6. Recommended minimisation alternatives
5.7. Summary of the alternatives
5.8. Other considerations
5.9. Appendices: diagrams of processes, used protocols, work sheets, etc.

5.1. Introduction and background

In this first section of the document, it is advisable to explain the motives and the context within which the company has proposed to carry out a MOED. The goals to be achieved through the carrying out of the diagnosis are described and a definition given of the methodology used for making the MOED.

5.2. General description of the company

A descriptive overview of the business should be given here, under the following headings:

Company details

The following have to appear:
- Registered name
- Address
- Telephone, fax and e-mail
- Details of official registration
- Type of activity
- Contact, together with the spokespersons who have been chosen.

It is advisable for both educational and practical purposes to include all of these data in the form of summarised charts and tables. *(Figure 6)*

Structure and organisation of human resources:

A flow chart should be included and a table to identify the different areas and personnel, above all because some of them may be particularly affected by the proposals being presented. *(Figure 7)*

General data and scheduled working hours *(Figure 8)***:**

These data refer to the workforce's in-house conditions:
- Staff characteristics
- Recruitment
- Scheduled working hours (shifts, hours/day, days/year).

Production

The general details of the company concerning the volume of output and turnover and the main products manufactured are more important than they may first appear.

The contrasting of production data with the values obtained for waste flows will give comparative ratios *per unit of production*; in short, it gives an indicative measurement of the environmental efficiency of the business. These ratios[31] become especially important if data are available that cover a group of companies in the same sector.

[31] In a study carried out on different companies in the paint industry, a ratio was established for the total waste generated in relation to annual output that ranged between 20 and 100 kg of waste per ton of material produced.

Figure 6

EXAMPLE OF A COMPANY'S DETAILS

Name of company:	FORMA, S.A.
Registered address:	c/ Taures, 7 - 034000 AVILA
Telephone:	555 55 55
Fax:	555 66 66
Main office:	c/ Taures, 7 - 034000 AVILA
Address:	c/ Taures, 7 - 034000 AVILA
Activity:	Stamping and presswork of metal parts
Identification no.	D-02/97
Date carried out:	October 1997
Year of reference for data:	1996/1997
Contact person:	Technical manager: Mr. Jaime Pérez; Manager: Mr. Francisco García

Figure 7

EXAMPLE OF AN ORGANISATION TABLE FOR A COMPANY

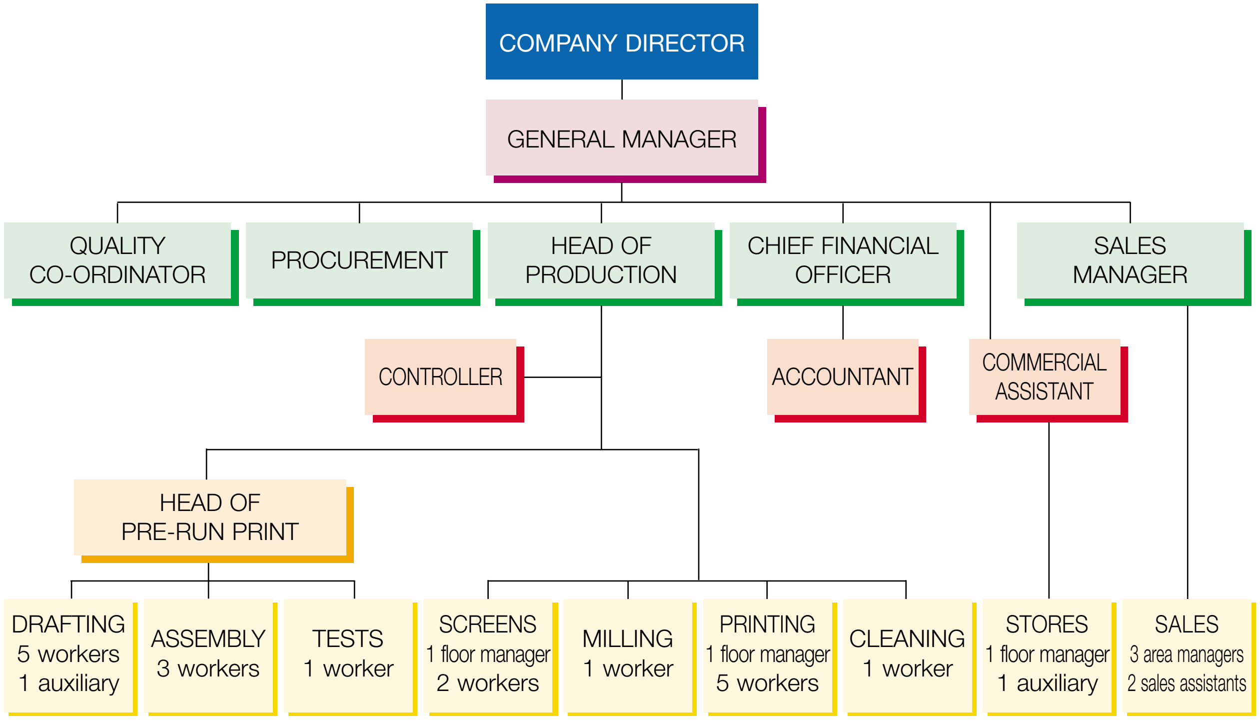


Figure 8

EXAMPLE OF GENERAL DETAILS AND WORK FORCE

No. of workers:	44	
Annual turnover:	3,600,000 €	
Size of company:	SME	
Job distribution:		
Stores location:	1	
Dispatch warehouse:	1	
Manufacturing:	26	
Workshop:	6	
Offices:	9	
Maintenance	1	

Hours/day:	24	
Days/week:	5	
Days operative per year:	225	
Hours/year:	5,400	
No. of shifts	4	
Shift times and average no. of workers:	Time: 5am - 1.30pm	10 workers
	Time: 1.30pm - 10pm	10 workers
	Time: 10pm - 5am	2 workers
	Time: 8am - 1pm/3pm - 6pm	22 workers
Months of peak activity:	Work is constant all year round	

TABLE OF PRODUCTION FIGURES FOR SMITH PAINTS DURING 1997

DESCRIPTION	T/YEAR	%
1. Plastic water-based paints	1,800	45.0
2. Solvent-based paints or gloss	1,155	28.8
3. X paints	1,045	26.2
TOTAL	4,000	100

Raw materials *(Figure 9)***:**

In the raw materials section, a description has to be given of the names and quantities of the main and secondary materials used in the production process, together with their most important characteristics as described in chapter 4.

However, as has been pointed out in numerous meetings between experts, it is important to avoid making long lists that have very little to do with the objectives of the MOEDs and take more account of the relative importance of classification, characterisation and use.

Companies are sometimes reluctant to give certain data. Here, the expert has to know how to substitute these data for others (equipment capacity, number of units produced) to try and give a true reflection of the company which can be used for comparing the feasibility of the proposed alternatives.

It is down to the expert directing the MOED to make proposals for simplifying the lists of general materials. In any case, the business has to define and specify them in order to start controlling its productivity itself. In accordance with this aspect, a raw material can be said to be significant in any of the following cases:

- When its volume represents more than 10% of the consumption of total raw materials.
- When it has a short expiry date.
- When it is dangerous.
- When it can easily be introduced into waste flows, due to its composition.
- When it is stored in non-returnable containers.

Figure 9

EXAMPLE OF RAW MATERIALS CONSUMED

Raw material	Developer	Fixer	Blocker	Emulsion
Subprocess	Drafting	Drafting	Insulation	Insulation
Source/supplier	Romires LTD	Romires LTD	Romires LTD	Karisel, LTD
Annual consumption	30 doses (5 litres per dose)	35 doses	160 Kg	73 Kg
Consumption/unit produced	1.75×10^{-5} dose/m^2	1.52×10^{-5} dose/m^2	2.3×10^{-4} Kg/m^2	5.42×10^{-5} Kg/m^2
Cost price	26 € /dose	26.32 € /dose	0.01 € /gr	0.015 € /gr
Total annual cost (€ /year)	780	921.2	1,600	1,095
Hazardous components for the environment Toxicity at:	Irritant *Hydrochinone:* DL_{50} oral (rat) 320 mg/Kg *Ethylenediamintetraacetate* DL_{50} oral (rat) 2,000 mg/Kg CL_{50} fish 320 mg/l 98h *Potassium hydroxide:* DL_{50} oral (rat) 273 mg/Kg	Irritant Toxicity at: *Ammonia thiocyanate:* DL_{50} oral (rat) 750 mg/Kg CL_{50} fish 200 mg/l 96h *Acetic acid:* DL_{50} oral (rat) 3,310 mg/Kg CL_{50} daphnia 47 mg/l 48h	Organic solvents Toxicity at: *Ethyl alcohol:* DL_{50} oral (rat) 7,060 mg/Kg DL_{50} cut. (con) 20,000 mg/Kg CL_{50} Inhalation 8,000 ppm 4h *Isopropyl alcohol:* DL_{50} oral 5,045 mg/kg DL_{50} cut. 12,800 mg/Kg	Irritant
Means of supply	Plastic pot (5 litres)	Plastic pot (5 litres)	Plastic pot (5 Kg)	Plastic pot (4.5 Kg)
Means of storage	In pots in drawing room	In pots in drawing room	On insulation shelves	On insulation shelves
Means of fransfer	Manual	Manual	Manual	Manual
Expiry	No	No	No	No
Alternatives	Other companies	Other companies	1 manufacturer: Sericol	Other manu-facturers
Return to supplier	Yes	Yes	Yes	Yes
Return of empty containers	No	No	No	No
Return of expired material	No	—	No	No

The importance of a raw material thus gets defined according to the volumes handled regularly and the associated degree of pollution and toxicity; its economic value may also be of interest.

Water consumption *(Figure 10)***:**

Water is a basic element in many businesses in its role as a raw material incorporated directly into products and processes, in terms of the auxiliary service that it provides (in cleaning, as a vector of energy transmission in steam boilers) and in the fundamental role that it plays in the main industrial waste flows: the liquid phase discharges.

This resource has gone from being an element that was hardly taken into account to becoming a truly “critical” resource, both in terms of supply —quantitatively and qualitatively— and of the dumping of waste into the public municipal water system, rivers or directly into the sea.

When dealing with the estimated or measured total consumption of water, the following need to be identified in a MOED:

- Sources of water and supply.
- Its distribution, use and specific information on consumption (by way of a diagram) through the quantitative differentiation of the values corresponding to:
  - The stages of production
  - The auxiliary processes
- The costs of supply and/or water off-take, including the cost of pre-treatment per process and the purification of wastewater.

A diagram of the supply, distribution, consumption and cost of water is of great help when presenting viable alternatives for minimisation, along with the educational advantages when real consumption data are used.

Energy consumption

The energy factor represents one of the key elements to be taken in account in the MOED and one which is generally forgotten.

In industry, this almost always falls into two main groups: thermal and electrical energy.

The following basic data must be included in the MOED:

Figure 10

DIAGRAM OF DISTRIBUTION, USE AND CONSUMPTION OF WATER IN A COMPANY

DISTRIBUTION, USE AND CONSUMPTION OF WATER AT SMITH PAINTS

ORIGIN	CONSUMPTION	UNITS	%
Municipal water supply	1,896	m^3/year	100

SITE OF CONSUMPTION	CONSUMPTION	UNITS	%
Cleaning	503.4	m^3/year	26.5
Sanitary	227.5	m^3/year	12.1
Process	1,165.2	m^3/year	61.4

ITEM	BASIS (m^3/year)	TOTAL (€)	€/m^3
Mains water	1,986	1,292.67	0.65

- The type of energy used
- The amount consumed
- The cost per unit and total expenditure

As a specific example, the energy consumption is given for a small company, together with the cost: *(Figure 11)*

Other aspects to be taken into account:

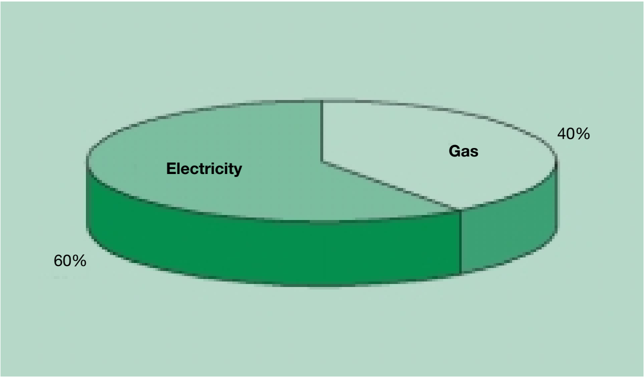
All information that is considered to be of interest concerning the business must be included in the documentation. This includes whether the company has an environmental policy; if it trains the operators and if so, what type of training is offered; if it has received any kind of certification from within the sector itself (food, pharmaceuticals, ISO 9000, environmental management system), etc.

Figure 11

DISTRIBUTION, USE AND CONSUMPTION OF ENERGY IN A COMPANY

RESOURCE	CONSUMPTION	COST
Gas	3,695,230 therms	53,646.54 €
Electricity	806,750 kWh	81,392.46 €
	Total cost	135,039 €

0.0145 €/therm
0.10 €/kWh



5.3. Description of the industrial premises

The basic aim of this section is to provide a general description of the company with its equipment and structure, where provision must be made for the plant distribution of manufacturing processes and especially of all the activities and areas that are important in terms of the diagnosis. For this reason, it is always interesting to include different types of distribution plans.

- Location of the company and the plant layout
- Details of the different areas, if necessary

In the different sub-sections, description should be made of the main characteristics of the production plant, storage areas, the offices and places where waste is stored.

5.4. Description of the activities, manufacturing processes and areas under diagnosis

This section must contain a detailed description of:

The production processes
- Equipment used
- Materials handling
- Operations involving handling, transportation and transfer, etc.

Auxiliary processes
- Cleaning operations
- Stores locations
- Maintenance
- Purification, etc.

It is advisable to divide the processes into sub-processes and include flow plans and charts.

These can include:
- General diagrams of the production process
- Diagrams with details of the sub-processes being analysed
- A definition of strategic and/or auxiliary processes that may produce environmental effects and be the object of a proposal for improvement (stores' location, production line, maintenance, cleaning, WWTP, etc.)

No waste flows should be included in this section, for these correspond to a specific section.

As a specific example, the production process diagram used by the manufacturing company TOTALPACK has been selected and broken down into the following sub-sections: (*Figures 12, 13, 14, 15)*

5.5. Description of waste flows

In this section, a description is given of the waste flows generated, the reasons why they are generated and the existing systems of management and treatment.

The waste flows must be recorded and an inventory made. Two classifications are considered, according to the type of company where the assessment is being made:

A. Describe the waste flows for each of the company's processes and sub-processes, and identify and quantify the waste, wastewater and emissions generated.

Figure 12

PROCESS DIAGRAM OF THE COMPANY TOTALPACK

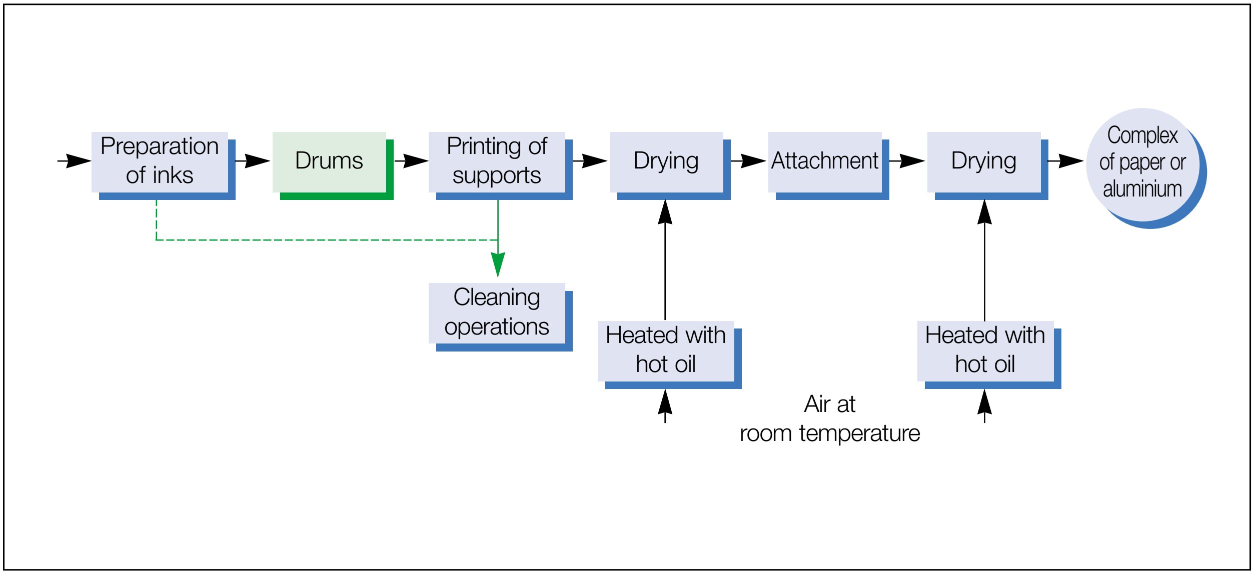


Figure 13

DIAGRAM OF THE PRINTING PROCESS OF THE COMPANY TOTALPACK

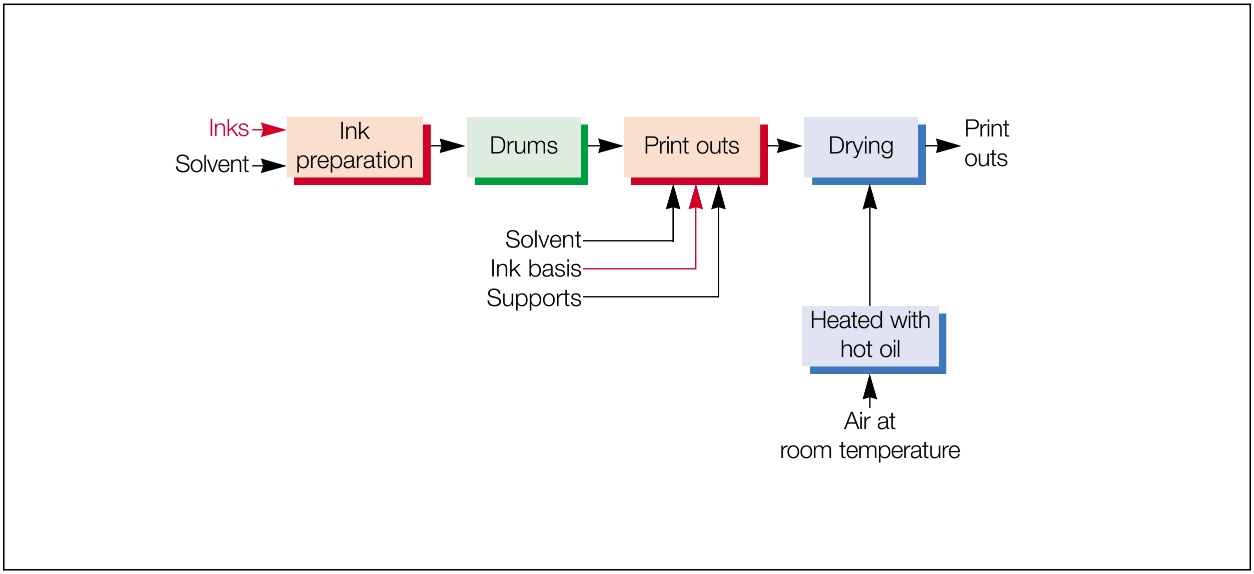


Figure 14

DIAGRAM OF THE LAMINATING PROCESS OF THE COMPANY TOTALPACK

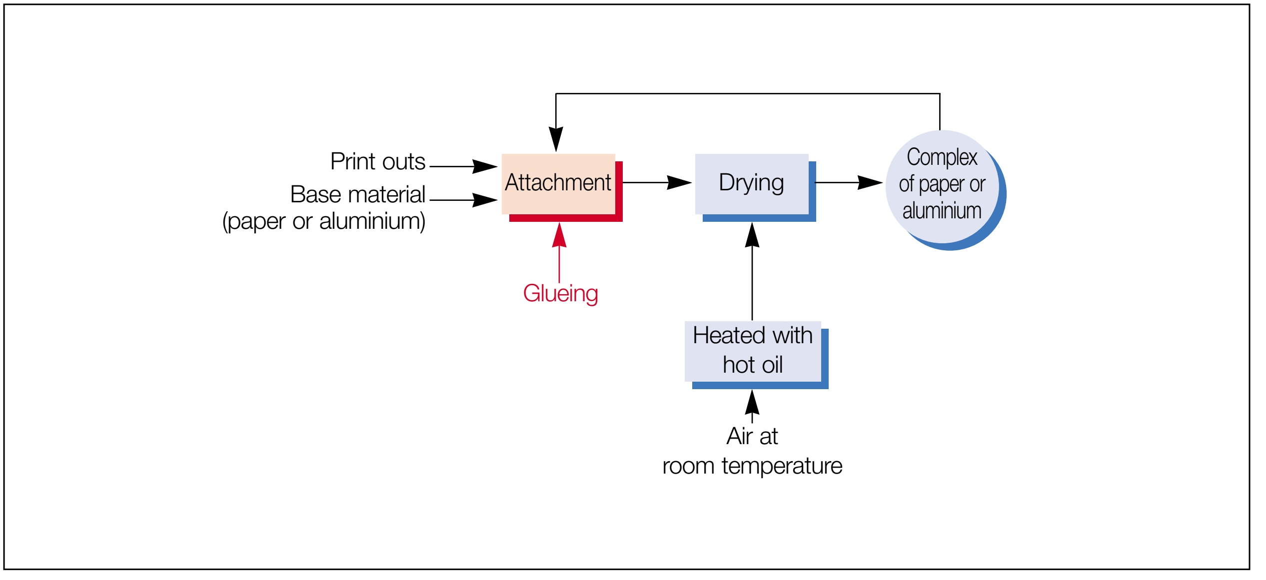
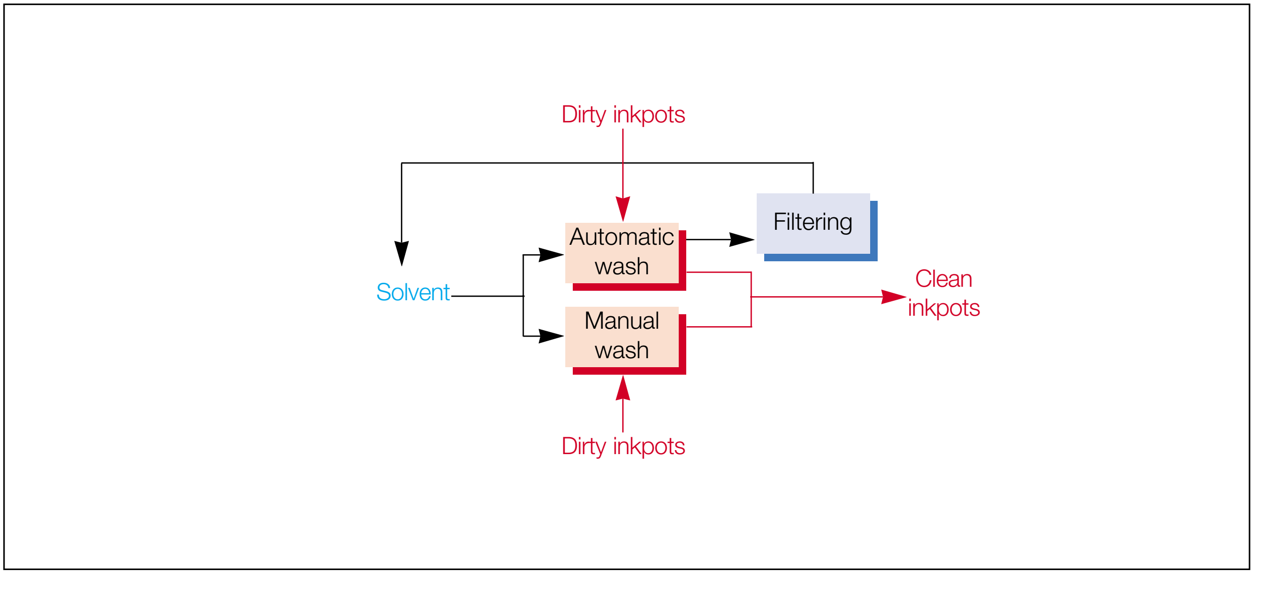


Figure 15

DIAGRAM OF THE CLEANING PROCESS OF THE COMPANY TOTALPACK



B. Describe the different environmental vectors under consideration (water, waste and air pollution) and identify the manufacturing processes where they originate.[32]

Independently of the methodology used, it is essential to fully identify the sources where waste flows are generated from the process analysis. The most important aspects to observe in this section are:

- An inventory of the waste flows.
- Identification of the sources of pollution (the particular point in the process).
- Evaluation of the waste flows (quantity, type, quantity per product unit manufactured, etc.)
- Current management expenditure.

While it is sometimes necessary to take samples and make analyses in the final process of defining a waste flow, it must be remembered that the MOED does not take into consideration whether the company is complying with legislation or not. *(Figures 16 and 17)*

5.6. Recommended minimisation alternatives

The MOED includes a detailed description of the different alternatives for reducing and/or recovering the waste flows generated by the company, together with a justification of the causes why these are recommended (technical and economic feasibility).

The proposals for both reduction and recycling at source must be clearly distinguished, both conceptually and in terms of presentation.

While many different types of alternative can be proposed, it is important to structure them and give priority to reduction at source over recovery and recycling at source:

- Reduction at source
  - Product redesign
  - Process redesign
    - –Good housekeeping practices
    - –New technology
    - –Material substitution (raw and/or secondary materials)
- Recovery and recycling at source

[32] One aspect that is worthy of consideration is the potential effects of soil pollution and aquifer contamination due to the bad management of these three points.

Figure 16

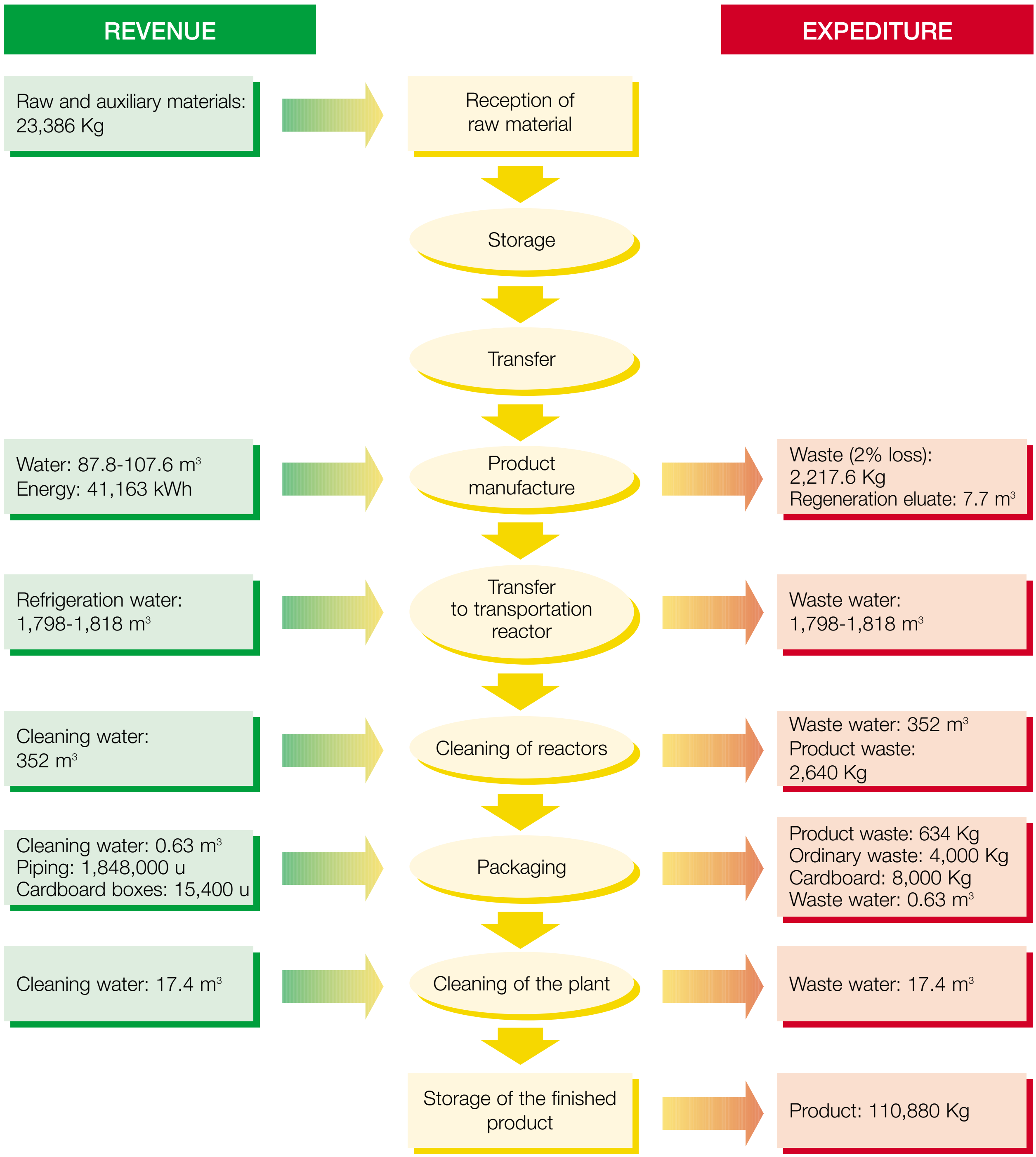
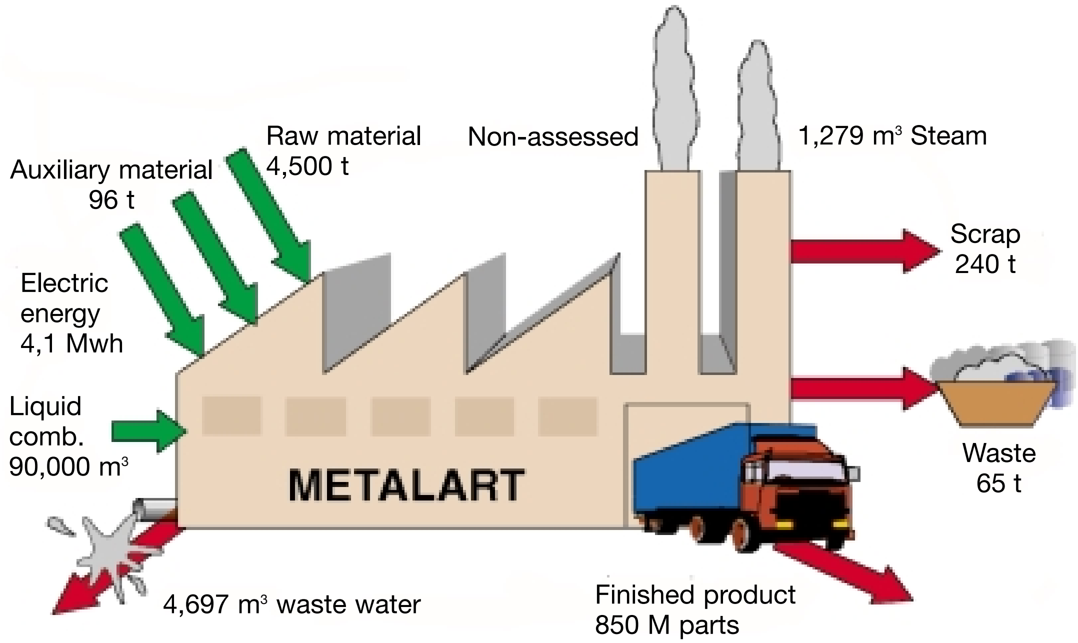

REVENUE
EXPEDITURE
Raw and auxiliary materials: 23,386 Kg
Reception of raw material
Storage
Transfer
Water: 87.8-107.6 m^3
Energy: 41,163 kWh
Product manufacture
Waste (2% loss): 2,217.6 Kg
Regeneration eluate: 7.7 m^3
Refrigeration water: 1,798-1,818 m^3
Transfer to transportation reactor
Waste water: 1,798-1,818 m^3
Cleaning water: 352 m^3
Cleaning of reactors
Waste water: 352 m^3
Product waste: 2,640 Kg
Cleaning water: 0.63 m^3
Piping: 1,848,000 u
Cardboard boxes: 15,400 u
Packaging
Product waste: 634 Kg
Ordinary waste: 4,000 Kg
Cardboard: 8,000 Kg
Waste water: 0.63 m^3
Cleaning water: 17.4 m^3
Cleaning of the plant
Waste water: 17.4 m^3
Storage of the finished product
Product: 110,880 Kg

Figure 17

GENERAL IDENTIFICATION OF THE MATERIALS, ENERGY AND WASTE FLOW BALANCES OF THE COMPANY METALART

Balance of material and resource consumption at METALART (1998)

For 1 ton of raw material, 53 Kg of waste metal is generated
For 1 ton of auxiliary material, 0.67 tons of waste is generated



For every minimisation opportunity the following will be included:

- A description of the alternative or alternatives proposed. Comparison with the current process.
- A justified quantitative estimate of the reductions that may be achieved.
- An estimate of technical feasibility.
- An estimate of economic feasibility.

Example of options for making reductions at source

Water consumption is very important at the SMITH PAINTS manufacturing company; after carrying out a MOED, a series of actions aimed at this point and involving reduction and recycling at source was proposed. The specific proposal of using hoses which close at the nozzle was made to reduce water consumption by around 15% (a saving of 75.5 m^3/year) together with high pressure machinery, which could bring about a reduction of 60% (a saving of 302 m^3/year).

Any reduction at source in the consumption of water minimises the subsequent treatment (externally or at source) of waste flows. *(Figures 18, 19, 20)*

Example of options for recycling at source

Two possibilities for recycling at source are recommended as options, both of them aimed at the reuse of cleaning agent used.

TABLE: SUMMARY OF THE OPTIONS FOR WATER REUSE AT SOURCE

OPTION	Water reuse (m^3/year)	Indirect saving in external treatment (€/year)	Estimated investment (€)	Cost of in-house + external treatment (€/year)	Pay-back period
Hypothesis 1: no prior reduction.					
Treatment of rinsing water	503.4 (1)	99,841.33	13,041.96	532.36	<1 year
Hypothesis 2: 60% prior reduction of initial consumption in a cleaning system.					
Treatment of rinsing water	201.3 (1)	59,896.86	13,041.96	211.71	<1 year

Cost of external water treatment: 0.198 € /kg
Cost of in-house water treatment: 0.54 € /m^3
Cost of external sludge treatment: 0.10 € /kg
(1) Supposing theoretical reuse of 80% of water

Figure 18

DIAGRAM OF DISTRIBUTION OF THE COMPANY SMITH PAINTS

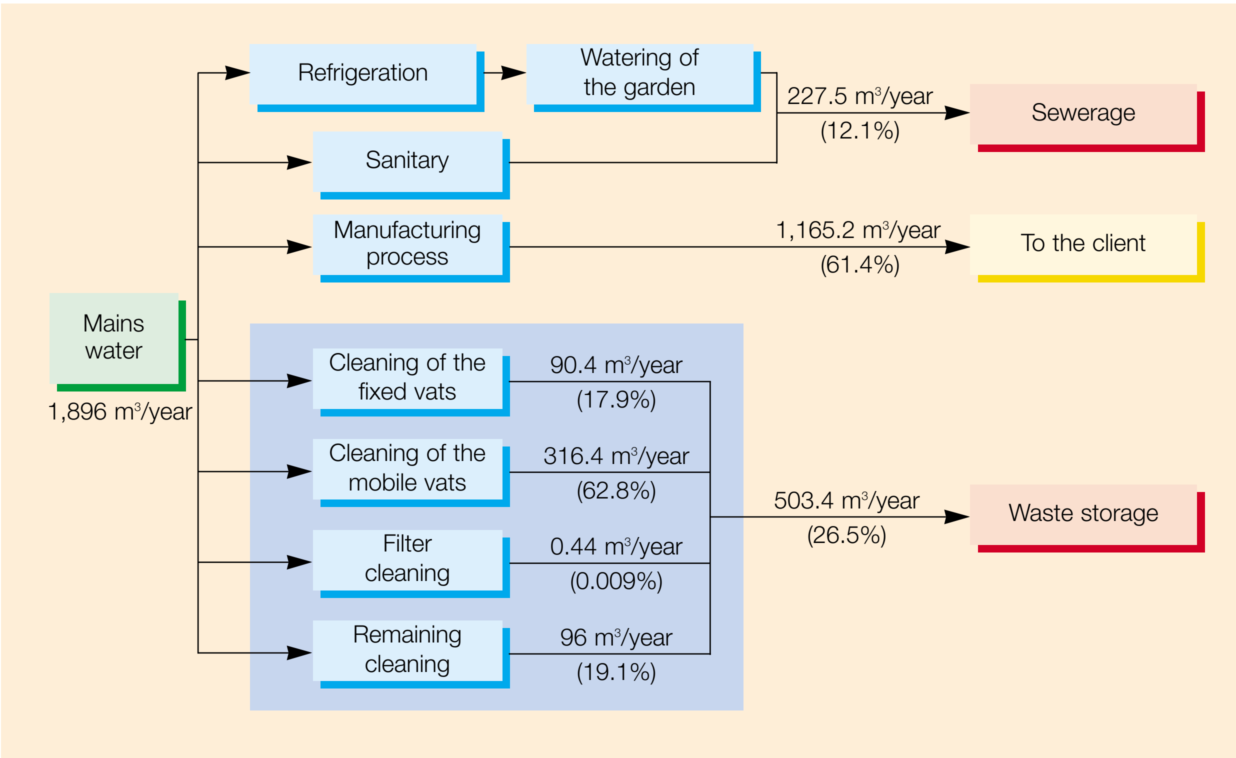


Figure 19

PREVENTION ALTERNATIVES AT SMITH PAINTS
OPTION 1: TAPERED ACTION HOSES

Estimate of reduction in water consumption 15%

External cost of water treatment: 0.198 €/Kg = 198,33 €/m³

503.4 m³/year → 15% → 75.5 m³/year

Cost of water: 1.075 €/m³

OPTION	Reduction in consumption (m³/year)	Saving due to reduction at source (€/year)	Indirect saving of external treatment (€/year)	Total saving (€/year)	Estimated investment (€)	Pay-back period
Hose	**75.5**	**81.22**	**14,974.21**	**15.055,43**	**2,085.22**	**2 months**

Pay-back period: 2,085.22 €/15,055.43 €/year = 0.13 years
0.13 years x 12 months = 1.6 months ~ *2 months*

Figure 20

REDUCTION AT SOURCE ALTERNATIVES AT SMITH PAINTS
OPTION 2: HIGH PRESSURE MACHINERY

Estimate of reduction in water consumption: 60%

External cost of water treatment: 0.198 €/Kg = 198,33 €/m³

503.4 m³/year → 60% → 302 m³/year

Cost of water: 1.075 €/m³

OPTION	Reduction in consumption (m³/year)	Saving due to reduction at source (€/year)	Indirect saving of external treatment (€/year)	Total saving (€/year)	Estimated investment (€)	Pay-back period
High press.	**302**	**324.89**	**59,896.86**	**60,221.76**	**1,526.57**	**1 month**

Pay-back period: 1,526.57 €/60,221.76 €/year = 0.03 years
0.03 years x 12 months = 0.36 months ~ *1 month*

A. **Reuse of cleaning water**

The prior application of the high pressure cleaning machine was recommended together with the two previous alternatives to bring about a higher proportion of reduction of water consumption. Nevertheless, the installation of hoses which close at the nozzle is also recommended at all off-take points for completing the cleaning operations that the high-pressure machine does not carry out.

The initial consumption of water for cleaning is as follows:

Annual consumption is estimated at 40,3 m^3/year for cleaning operations, on account of the addition of 20% of the clean water in the decontamination cycle. The cost is estimated at 0.54 €/m^3 per internal treatment of water, plus 0.10 €/kg per external sludge treatment (an estimated proportion of 1 kg of sludge plus coagulants per 200 litre drum of water with paint residue). *(Figure 21)*

5.7. Summary of the alternatives

To help in the identification of the proposals and the decision-making process, the MOED should conclude with the graphic presentation of a table that summarises the proposed alternatives, accompanied by the estimated economic evaluation including the estimated minimum pay-back period.[33]

As an example, the summary is given for all of the alternative proposals for SMITH PAINTS *(Figure 22)*

Opportunity	Alternative	Cost	Pay-back period
Opportunity 1	Alternative 1	€	Years
	Alternative 2	€	Years
Opportunity 2	Alternative 1	€	Years
	Alternative 2	€	Years
	Alternative 3	€	Years
Etc.	Etc.	Etc.	Etc.
TOTAL		€	**ESTIMATED PAY-BACK PERIOD**

[33] See appendix 2.

Figure 21

ALTERNATIVE PROPOSAL

Alternatives for recycling at source at SMITH PAINTS
OPTION 1: Recycling of cleaning water

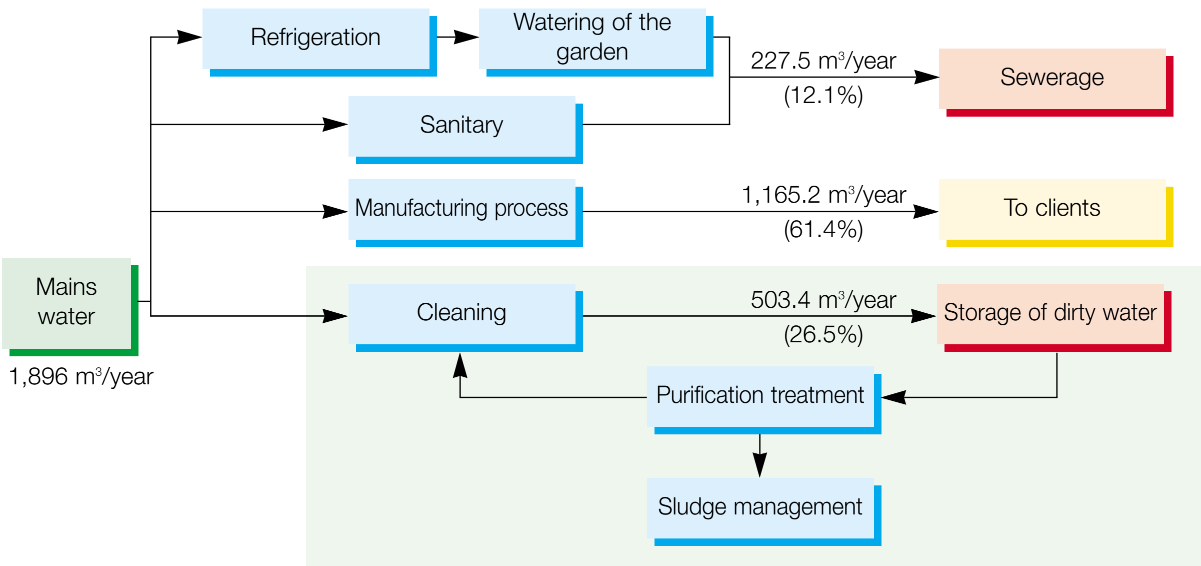


Figure 22

SUMMARY OF THE PREVENTION OPPORTUNITIES OF THE COMPANY SMITH PAINTS

DETECTED MINIMISATION OPPORTUNITY	ALTERNATIVE PROPOSAL	GUIDELINE COST (€)	PAY-BACK PERIOD
Minimisation of cleaning water	Use of tapered action hoses	2,085.22	2 months
	Use of high pressure machinery	1,526.57	1 month
Recycling of cleaning water	Recirculation prior to purification	13,041.96	<1 year
	Recirculation with high pressure machinery	13,041.96	<1 year
	TOTAL	29,695.71	

5.8. Other considerations

During the course of the work, other alternatives often arise that cannot exactly be considered as minimisation. Without going into detail, a qualitative description should be made of the alternatives that, even though they do not strictly involve pollution reduction and recycling at source, permit actions to be orientated towards achieving the correct management of waste flows, despite the fact that they do not constitute the essential aim of the MOED.

It is here in this section where alternatives to valuation, as by-products or external valuation, end treatment to improve the existing measures, etc. can be identified.

It should also be pointed out that companies being diagnosed can ask consultants for guidance concerning the legal situation of the business and the environment. Although this aspect does not form part of a MOED and must not form part of the report, it is feasible for it to be summarised separately.

5.9. Appendices

In the final report, it is advisable to include the work sheets, that are handed on adequately filled in.

It is advisable to specify information on equipment, products, technology and suppliers proposed in the alternatives, because the MOED must be above all a practical tool.

Information should also be included as guidance on the safety records of certain products, plans, specifications, etc.

It is not advisable, on the other hand, to include plans or flow charts of the processes in this final section, given that they should be inserted in the corresponding sections of the text itself, for layout and comprehension purposes.

6 The closing stage and monitoring of the MOED

6.1. The final report

The descriptive data in the final report of the diagnosis will be verified by the company receiving the report. Once this formality has been concluded, the team of experts writes up the final draft and hands over the final documents.

It is highly advisable to propose that the business' management team organise a session to present the study and the main proposals included in the MOED, as well as to clarify any doubts. This is a very important aspect that often gives very good results in the process of integrating pollution prevention and reduction programmes into the business' environmental management.

Formally speaking, the work of diagnosis ends in the closing stage, for implementation of the proposed alternatives by the company involves a different level of decision-making.

6.2. Follow-up plan

The worst thing that can happen to a MOED on becoming a large document is for it to be forgotten in some file or on a shelf without it having been put into practice.

In the majority of cases, however, this does not happen. It should be remembered that the company has done the MOED with the intention of reducing its environmental impact and optimising its business management. The results presented in the MOED will be thus too appealing to not continue with it.

Consideration should be given to the fact that options for prevention are usually introduced gradually, as is mentioned in the opening chapters of the book.

The possible synergistic effects of the implementation of diverse alternatives should also be emphasised.

When setting actions in motion for implementing the proposed alternatives, it is advisable for the company to assign an in-house person to be in charge of the tasks of checking and planning. Likewise, he or she should also make a periodic check of the programmes and actions, verify the level of fulfilment and the results of the measures that have been applied, and prepare a programme for the year's goals.

In this way, the company guarantees that the minimisation program is periodically updated.

As has already been mentioned, the alternatives can be implemented progressively. This enables records and proof of the improvements made (reduction in waste flows, economic savings) to be obtained, at the same time that anticipated expectations and final results can be compared.

It has also been said, however, that cleaner production is not static.

It should be taken into account that the development of technology that is more respectful of the environment is an emerging market and, therefore, improvements aimed at preventing and reducing pollution at source are constantly appearing. For this reason, from the company's point of view, pollution prevention must be understood as being a process of continual improvement that never ends and that needs to be maintained via the study and continuous control of processes.[34]

Figure 23

PROCESS OF CONTINUAL IMPROVEMENT

[34] The dynamics of industrial processes mean that the best available techniques in different sectors need to be redefined and introduced into business activities as new technology appears. As an example, in the case of EU countries, Directive 96/61/EC on pollution prevention and integrated control already takes this case into account.

7 MOEDs and their relation with other environmental management tools

It is undeniable that an interrelationship exists between the different tools for environmental management. Rather than incompatibility, this interrelationship often means complementarity when they are used in the correct sequence, at the right time and with the appropriate goals for each phase of the ongoing development of the company.

7.1. MOEDs and diagnoses for the implementation of environmental management systems

An environmental management system (EMS) is the part of the general management system that consists of the policy, programmes, aims and goals, organisational structure, responsibilities, practice, processes and resources for the management of significant environmental effects of organisations.

The implementation of an EMS starts with an overall preliminary analysis (initial diagnosis or review) that gives the current situation of the organisation in terms of the environment. Prior diagnosis is compulsory in the case of certifiable EMSs.

The diagnosis consists of a review of all of the activities of the company, with regard to income, processes, outward financial flows and the organisation itself. The relevant impacts and the degree to which the company complies with standard environmental regulations also need to be identified.

The diagnosis is helpful for identifying the strong and weak points of the organisation and is the basis for establishing the aims of the company's environmental management programme.

- Unlike the MOED, which incorporates alternatives and options for preventing and reducing pollution at source, a diagnosis with this kind of goal gives an account of the current situation of the company in terms of the environment and the regulatory thresholds that may be established.
- The diagnosis reviews the degree to which legislation is being complied with, which is something that is not included in the MOED, as is explained in chapters 3 and 4.
- The MOED, on the other hand:
  - Can be a good starting point for implementing or developing an EMS, for it provides information about the environmental aspects which will be important and therefore need to be accounted for in the EMS.

–It is a tool that identifies the points that can be improved and provides the setting for the start of the process of continual improvement that an EMS requires.

7.2. Environmental audits and MOEDs

Although the definition of an environmental audit (EA) as an objective, systematic review that provides documentary evidence of the environmental behaviour of an organisation may be valid for all countries, diverse approaches, aims, requirements and methodologies associated with this tool for environmental management do exist. This means that the approach and form of implementation may vary from one country to another.

- The purpose of the review that is carried out when doing an EA can take different goals into account according to the diverse approaches and ways that the tool can be used. Examples include the detection of the non-compliance of application regulations (requirements that, apart from legislation itself, can include other international standards or standards pertaining to the organisation being audited)[35] by the organisation; the identification of pollution generation and inefficiencies that interfere with performance improvement; or the review of processes in order to detect opportunities for reducing pollution at source and to propose viable alternatives for minimisation, with account always being taken of the options'technical and economic feasibility.[36]
- Some of the aims of the EAs described concur with those of the MOED, which reviews processes, waste flow generation, the use of resources and points where opportunities for reducing pollution at source may be possible, as well as proposing feasible alternatives for minimisation. However, both tools complement each other, for the MOED does not provide information on the degree to which the company complies with legislation.
- In terms of the variables and analytical elements that an EA can incorporate, according to the definition given of it in different places, can include the identification of waste flows (origin, type, volume, etc.), resource use (raw materials, water and energy), the conditions of safety at work, and the detection of weak points (inefficiencies in the process, inadequate management, etc.) and potential improvements (aimed at preventing and reducing pollution at source, reducing the use of resources and of promoting efficiency, end-of-pipe treatment, and increasing the levels of safety and reducing risks at work).[37]

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[35] Eg. the environmental policy defined by the company or group of companies to which it belongs.

[36] By way of example, the audit for cleaner production that is used in Turkey and environmental auditing that has been carried out in several companies in the Lebanon deal with all of the aforementioned purposes, so their definition of the EA is very broad.

[37] When identifying improvements, some EAs in the Mediterranean establish clear priorities to emphasise the prevention and reduction of pollution at source as opposed to end-of-pipe treatments (as the MOED does). In some cases, an analysis is made at the end of the feasibility of the options being proposed from both a technical and as economic point of view, as happens with the MOED. These priorities have been taken into account in the case of guidance being given to companies in Tunisia on cleaner production, audits for cleaner production being done in Turkey and the environmental auditing of various companies in the Lebanon.

- The composition of the auditing team may vary substantially according to the approach of the EA. It can either be formed of outside experts or company personnel to undertake the review or there can be a joint collaboration between both.[38]
- As is mentioned in section 3.3 of the manual, the MOED is designed to be carried out by an external consulting team, at the same time that it establishes an active relationship with the company receiving the MOED. To understand how the EA and the MOED relate together, EAs that give priority to assessment by outside experts, and that count on the collaboration of personnel from the company, direct their efforts towards the same purpose as the MOED.
- Finally, with regard to the methodology and the tools for carrying out an EA, a range of tools are used,[39] many of which can be applied together, including visits to the company, interviews with the managerial team and personnel, and the filling out of check-lists to obtain data on the company. A series of defined stages is adopted for dealing in general with the planning and organisation of the EA, preliminary guidance, the feasibility study and finally implementation.[40] This structure in stages is thus similar to that of the MOED described in sections 4 and 5 of the manual, where information for carrying out a MOED and a presentation of the structure of the document are given.

7.3. MOEDs and life cycle assessment

Life cycle assessment (LCA) is a series of techniques for identifying, classifying and quantifying pollutional loads and the material and energy resources associated with a product, process or activity from the moment it is conceived through to its disposal. The LCA seeks to assess and put the possibilities of environmental improvement into effect using the values of an initial inventory that endeavours to detect "all" of the impacts that are and can be associated with the product, assess them, and carry out procedures aimed at reducing them.

The life cycle of a product includes the extraction of the raw materials, its manufacture, transportation, use, reuse, recycling and the disposal of the product's waste. This gives it a very special character because of the considerable transcorporate component that notably increases the complexity of the analysis.

- MOEDs and LCAs provide technical and economic information on the existing options, but whereas the MOEDs focus on the company and the actions for preventing and reducing pollution at source, the LCA incorporates the environmental effects identified over the whole geographical area and time scale accepted within the scope of the study.

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[38] On the one hand, some reviews, for example the self-monitoring process used in companies in Egypt, envisage the subsidiary help of external consultants only when beginning the review of the company, with encouragement being given to self-evaluation by the personnel of the company itself. EAs being carried out in Turkey, Lebanon and Tunisia, on the other hand, are based on assessment by outside experts, although company personnel do also collaborate.

[39] RAC/CP has compared the different ones in the Mediterranean area through the National Focal Points and there is no substantial difference.

[40] Audits for cleaner production that are carried out in Turkey, for example, reach the implementation stage.

- The final purpose of both tools is to assess and carry out procedures orientated towards reducing associated environmental impacts.
- While the MOED as a tool is simpler than the LCA (and it is also more flexible, faster and more economical), the information gathered in a MOED can be very useful for subsequent LCAs undertaken for the same process or for a product manufactured by a process analysed in the MOED.

7.4. The MOED and voluntary agreements

Two very important elements for achieving sustainable development are the collaboration and shared responsibility of the different parties involved. Within this context, the signing of voluntary agreements between government authorities and companies and business associations has been fostered in recent years.[41]

The purpose of these agreements aims at establishing a period of time within which a particular company or business sector achieves certain levels of disposal, emission or waste generation. During this period of time, the company or companies adopt the improvements that are necessary for complying with the stipulated goals.

These agreements can also have a broader meaning and seek the collaboration of those involved in order to establish the technical and organisational measures that contribute to continual environmental improvement in the sector, and goals that are coherent with the realities of business and improvements that can be attained by industry, avoiding the implementation of command and control measures.

- The aims that orientate the development of a MOED are, in principle, not set within the framework of legislation but are based exclusively on voluntary criteria for making improvements in order to reduce waste flows. The alternatives to pollution prevention and reduction at source recommended in the MOED can help to avoid the increase in size of corrective facilities and even do away with them.
- Given their flexibility and prevention objectives, it is advisable for the signatories of voluntary agreements to start exploring the possible ways of preventing and reducing pollution at source that are provided by MOEDs before devoting themselves to treating and managing specific types of waste flow indefinitely.

[41] European Environment Agency. *Environmental agreements - environmental effectiveness,* 1997.

8 APPENDIX 1: Workgroups

The workgroup is a tool aimed at studying the alternatives for the reduction of pollution at source in an industrial sector or geographical area.

The workgroup is made up of different companies in the same industrial sector or subsector or in the same geographical area, together with an expert and occasionally a business, trade or local association that provides logistic support for the project.[42]

A workgroup can be formed on the initiative of the group of companies itself or of a local association, guild, a chamber of commerce, etc. The ideal number of participants is between 6 to 12 companies to be able to benefit from the synergies that are created and, at the same time, make it operative for all of the participants. The duration of a workgroup is around six months.

The workgroup includes the following elements:

- Periodic group meetings where the exchange of knowledge and experience is encouraged, and where the most highly recommended, possible environmental alternatives for a sector or geographical area are discussed. Clean technologies and alternative products are presented for all of the companies and experts are invited to develop special subjects concerning aspects of an industrial process, a certain kind of material used therein, etc.

  The meetings are prepared and led by the expert and attended by one representative from each company. An atmosphere of trust is created at the meetings which facilitates the exchange of experience between companies.

  The companies participating in the workgroup need to be homogenous enough so that subjects of common interest can be found because a series of proposals is made in the meetings that each company can apply freely and that can be applied to other companies in similar circumstances.
- The carrying out of an individual MOED in each company taking part, with the aim of establishing the specific options available to each company for preventing pollution at source and making the appropriate recommendations.

[42] Projects can be reinforced and their results enhanced when promoted by, and with the participation of government environmental authorities.

- The drawing up of a final report, including an attached summary of the matters dealt with at the meetings and a description of the overall environmental situation of the participants, including a description of the existing alternatives for pollution prevention and the level at which they are currently being applied.

The results of the workgroup are thus twofold in that each company receives its own diagnosis that enables it to orientate appropriate projects for preventing pollution, as well as a document that gives an overview of the detected opportunities and recommendations made in each case, which can often be identified and reproduced in other companies.

In terms of the benefits of participating in a workgroup, it provides a company with a MOED that focuses on its own particular production process, as well as enabling it to exchange experience and knowledge with other companies and the experts that are hired, and to become aware of its environmental situation in relation to the sector.[43]

For particular sectorial or local business associations, a workgroup provides, on the one hand, knowledge about the sector or geographical area, its environmental repercussions and alternatives for minimisation and, on the other, knowledge of the concerns and interests of the companies taking part, together with the possibility of formalising voluntary agreements.

[43] The participation of a government expert in the meetings can help the government authorities to become aware of the concerns of the industrial sector or geographical area under study.

9 APPENDIX 2: Analysis of the technical and economic feasibility

9.1. Process of analysis

Once the opportunities for improvement have been identified, a feasibility assessment has to be carried out in the diagnosed company. The aim of this analysis is to provide the company with basic information on the technical and economic implications involved. The company can decide on the implementation strategy for the different alternatives proposed according to a series of factors such as the economic resources, human resources, the corporate culture, the seasonal nature of the activity, etc.

The **technical feasibility** is analysed first to enable this assessment to follow a logical order because the alternative to be implemented may be rejected as a result of this analysis.

If the conclusion of this technical feasibility assessment is that there are no outstanding difficulties preventing it from being implemented, an assessment is then made of the **economic viability** to provide the company being diagnosed with suitable information on the economic aspects concerning the application of the alternative.

Figure 24 gives the criteria that are applied in the process of analysing this feasibility. These criteria serve as a guide and can be modified by the expert according to the situation in each country.

9.2. Technical feasibility

The expert must take the particular characteristics of each company into account when assessing the technical feasibility for this is subject to special conditions that may prevent the alternative under study from being implemented as a result of the particular conditions in the company.

Some of the technical implications can easily be got around by small changes being made to the installations that the expert must estimate in economic terms.

The aspects that at the very minimum need to be analysed are as follows:

- Changes that the applied alternatives may cause to the product through any variation in the function for which it was designed.

- The availability of space in the plant for any additional installations required.
- The type of preparation necessary for any additional installations, together with any services that may be necessary for their implementation (water for processes, water for refrigeration, steam, electricity, compressed air, inert gas, etc.)
- The time necessary for the installation and set-up, with details of the drop in production that will occur as the result of lines affected being stopped.
- The flexibility of the new process in the production phase with a view to introducing new changes in the future.
- Compatibility of the proposed alternative with the corporate culture of the company.
- Sufficient knowledge of the proposed technology, the necessary degree of specialisation and the personnel required for it to function.
- The availability of dealers for the new processes, and for the equipment and materials that will be used.
- The maintenance that the new equipment will need, and qualified personnel to do this.
- Legal and administrative implications of all of the changes.

9.3. Economic viability

The aim of this analysis is to assess the main economic aspects concerning the implementation of the alternative in the company.

Bearing in mind that the MOED is a flexible tool and that it focuses on giving the company being diagnosed the most relevant information, it makes no sense for this economic analysis to include all of the factors that may directly or indirectly affect the future profitability of the company. Such an in-depth study would convert the resulting MOED report into an excessively long document and even make it illegible and incomprehensible in certain cases.

All the same, there is a series of elements, which are subsequently explained, that cannot be left out when analysing the economic viability of each alternative that is to be implemented.

A large number of tools have been developed. The most basic, yet at the same time the most appropriate one for using with the MOED is the investment payback period.

9.3.1. *Investment payback period (IPP)*

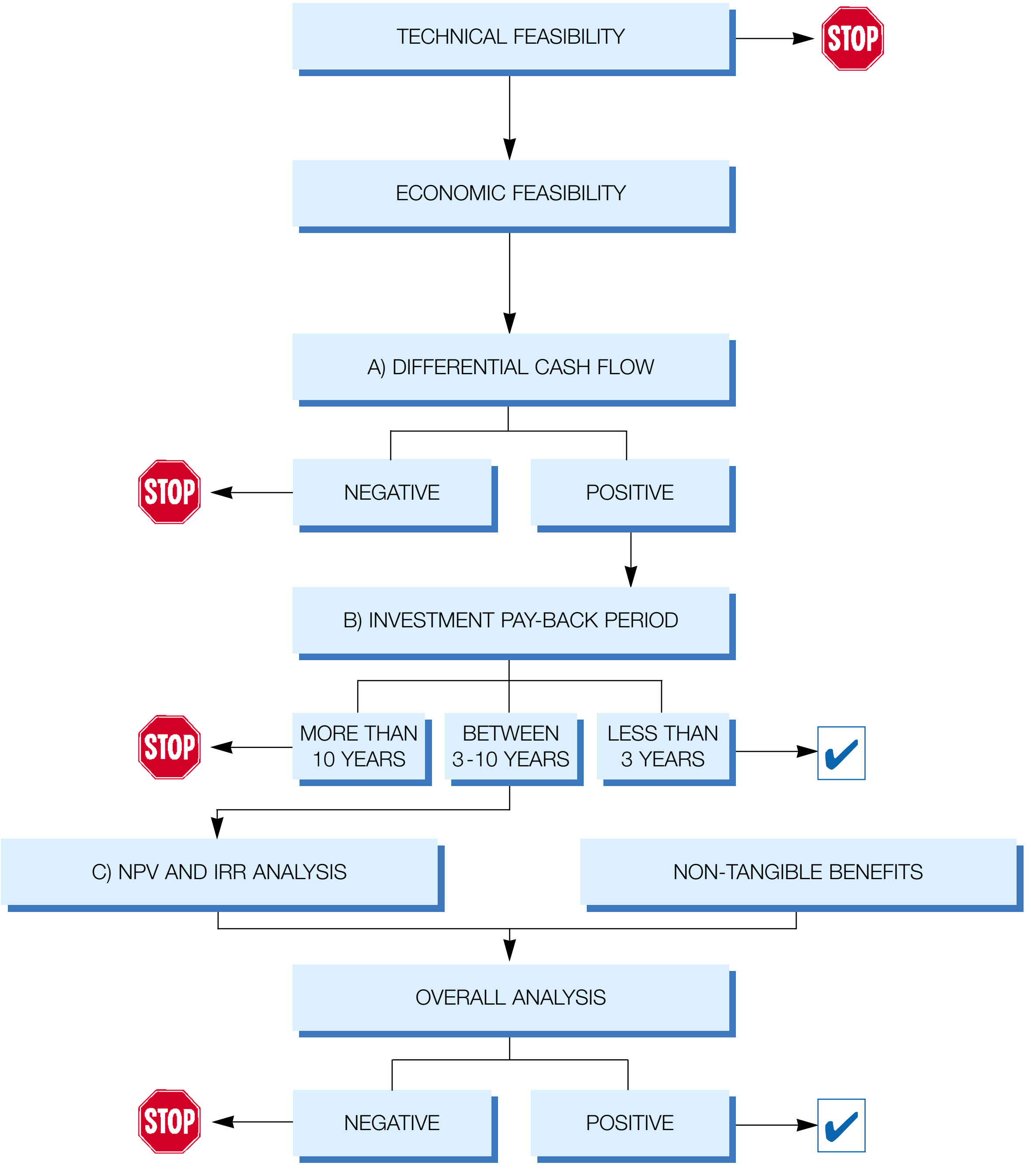
This is defined as the necessary time for the accumulated differential cash flow to offset the investment made in the project.

The differential cash flow is defined as the net saving attributable to the implementation of the proposed alternative compared to the current production process.

The entrepreneur can thus know the moment when changes introduced in the company begin to produce a net profit for the operating performance income statement.

Figure 24

FEASIBILITY ANALYSIS PROCESS



It is calculated in the following way:

$$IPP = \frac{\text{INVESTMENT MADE}}{\text{DIFFERENCIAL CASH FLOW}}$$

The result is a time period that is considered economically attractive when the change takes less than three years. If the IPP is more than three years, the company should undertake an indepth economic analysis using the tools that are explained below.

When calculating the IPP, consideration must be given at the very minimum to the following sections:

Investments and their derived costs:

This includes all of the investments required to implement the alternative:

PURCHASE OF EQUIPMENT FOR PROCESSES cost / taxes, insurance, customs duties / spare parts transportation
SITE MATERIALS AND PREPARATION demolition, dismantling / buildings and accessories / electric material / piping / insulation
CONNECTION TO PUBLIC UTILITIES electricity, diesel oil / steam / refrigeration and water for refrigeration / water for processes / air plant / inert gas
ADDITIONAL INSTALLATIONS storage / dispatch of products / laboratories, analysis
ENGINEERING, CONSULTANTS
CONSTRUCTION AND INSTALLATION supplier / contractor / fitter / site management / own equipment
SET-UP supplier / contractor / fitter / training / pilot trials
TRAINING OF PERSONNEL
LICENCES AND AUTHORISATION
ROYALTIES, PATENTS AND R+D
TAX DERIVATIVES (+/-)
INCIDENTAL EXPENSES

Operating expenditure

This includes all of the variations in the operating expenditure that may occur when the alternative is implemented, and that will entail a different cash flow for the company.

REDUCTION OF COSTS FOR TREATMENT/ELIMINATION taxation / transportation costs / costs of internal treatment (including collection) costs of external treatment / costs of storage material / analysis costs licence costs
VARIATION OF MATERIAL INPUT COSTS raw materials / additives / auxiliary products
VARIATION IN THE COST OF PUBLIC UTILITIES electricity, diesel oil / steam / refrigeration for processes and in general / water for processes / air plant / inert gas
REDUCTION IN OPERATING COSTS AND INTERNAL TREATMENT maintenance / cleaning / personnel
REDUCTION IN THE COST OF INSURANCE
REDUCTION IN THE COSTS OF POOR QUALITY

9.3.2. *Other tools for assessing profitability*

These tools are used for the MOED feasibility analysis, when their use is considered necessary and depending on the criteria established in this appendix.

9.3.2.1. Net present value (NPV)

This is the updated value of the differential income generated every year.

It represents the income generated during the life of the investment measured from the initial time it was made.

$$\mathbf{NPV} = \sum_{i=0}^{n} \left[\frac{\text{DIFFERENTIAL PROFITS (i)}}{(1+r)^i} \right] - \text{INVESTMENT}$$

r: interest rate (the cost of the money for the company, or the cost of the opportunity for its financial resources)

n: economic life of the investment being analysed

i: sum of all of the years of a product's life *(n),* with the year when the investment was made being considered as 0.

The NPV must be positive, because this means that the investment is profitable, and the bigger the value, the more interesting the investment will be in economic terms.

9.3.2.2. Internal rate of return (IRR)

This is the interest when the value of the original investment equals the reappraised value of the differential profits accumulated each year.

This is calculated with NPV being equal to zero.

$$0 = \sum_{i=0}^{n} \left[\frac{\text{DIFERENTIAL PROFITS (i)}}{(1 + \text{IRR})^{i}} \right] - \text{INVESTMENT}$$

n: economic life of the investment being analysed

i: sum of all of the years of a product's life (n), with the year when the investment was made being considered as 0.

9.3.2.3. Intangible benefits

When making the decision to implement a change in the production system, the entrepreneur needs objective, assessable elements to help direct his/her actions. However, one should never forget the series of benefits accruing at the same time for the company that result from this change. These are the so-called intangible benefits.

It is difficult to quantify intangible benefits and they can normally only be assessed via qualitative criteria.

They are frequently just as important as the profitability analysis, if not more so. For this reason, they can be determinant when implementing an alternative that may apparently not be profitable enough.

The most common intangible benefits that are generated as a result of the implementation of alternatives for pollution prevention and reduction are the following:

- Impact on the environment.
- Improved competitiveness with respect to the rest of the sector.
- Improved quality of the product.
- Improved corporate image and improved relationships with dealers and suppliers, clients, government authorities and people living nearby.
- Improved control of the productive process, while it also encourages information to be obtained for other actions in the future.
- Reduced risk of penalties.
- Effect on the health of the workers.
- Improved conditions at work, reduced risk of accidents and the increase in the level of satisfaction and training of the personnel.
- It facilitates the compliance with future legislation.
- Reduced possibility of future liabilities concerning waste or emissions generated by the company, such as accidents in the transportation of waste, leaks from storage tanks that pollute the soil, etc.

10 APPENDIX 3

Evaluation of the opportunities for reduction and recycling at source and other forms of pollution[44] prevention generated by the industrial plant of Decayprint, SA[45]

44 It must be borne in mind that the opportunities for reduction and recycling at source and other forms of pollution prevention described in this appendix are applicable in this particular case. In other cases, depending on the characteristics of the company and its location, other opportunities may prove more appropriate from both a technical and an economic point of view and yield greater benefits.

45 This example is taken from the final report of a MOED carried out by BIOMA CONSULT with their consent. The name and data of the company diagnosed, along with figures have been changed to ensure confidentiality. For the same reason, appendices 1, 2, 3, 4 and 5 of MOED have not been included.

Table of contents

1. Introduction. Background

DECAYPRINT, SA, is a company with premises in the municipality of and a warehouse in . It is an SME operating in industrial painting for third parties, of plastic surfaces, for the motor and motorcycle sectors.

As a company concerned with improving continually in every aspect, some time ago DECAYPRINT, SA, implemented an ISO 9002-quality management system.

Recently, it has decided to go for integrated management in all the environmental aspects of its activity, through the implementation and development of the ISO 14001 and EMAS systems. Prior to this, DECAYPRINT, SA, has undertaken this **Assessment of the Opportunities for reduction and recycling at source and other means of pollution prevention,** understanding this minimisation to be the primary tool of environmental management.

2. General company description

With an annual turnover of less than 2.2 million €, DECAYPRINT, SA, has a workforce of approximately 35, 30 of whom are involved in the productive process. Production is carried out 222 days a year, in a single shift, with a daily work schedule of 8 h 30 min. The part of the company that deals with production is usually closed in August and a few days in December. During this time, maintenance is carried out. This data is summarised in the following table.

Table 1

General data	
Annual turnover	<2.2 million €
Total number of workers	35
No. of workers in production	30
Work days a year	222
Number of shifts	1
Work schedule	8 h 30 min
Holidays	August and days in December

DECAYPRINT, SA's activity is carried out in two continuous paint lines and a static booth, used for very short series. The base material in every case is plastic.

Line 1 has 3 booths, where primer, colour and varnish (two coats) are applied. Line 2 has 2 booths, where colour and varnish are applied. Both lines have pressurised booths with curtains of water, equipped with filters for the water and air entering and leaving the booth.

The static booth works dry and has air filters at the entrance and exit.

In all 6 booths, paint is applied manually using spray guns which work on warm compresseed air.

The company uses liquid paint, almost always acrylic and polyester with two components.

The base material painted, as stated before, is always plastic. *Table 2* contains information on the different types of plastic and its percentage of application.

Table 2

Type of plastic	Percentage of application
Acrylonitrile-butadiene-styrene (ABS)	70
Polybutylene terephtalate (PBTP)	20
Polypropylene (PP)	<10
Polycarbonate and polyamide (PA)	Rest

2.1. *Raw material consumption*

The fact that DECAYPRINT, SA, works exclusively for third parties directly affects the purchase of raw materials. In this respect, it must be pointed out that the materials used in the process (type and brand of paint, amount purchased, etc.) are always determined by the client, who is also responsible for bringing the different types of plastic to the facility for painting.

As for the solvents, these are recommended by the paint manufacturers, both in winter and in summer.

The raw materials used are the following brands: (primer), and (paint), and (varnish and application solvent).

DECAYPRINT, SA's annual raw materials consumption can be seen in *Table 3.* These data, and others, are supplied by the company, and are for 1997.

Table 3

Raw material	Annual consumption (kg)	Supplier	Price (€/kg)	Cost year (€)
Primer (base paint)	6,020	* * * *	6.01	36,180
Catalyst (primer)	1,500	* * * *	9.01	13,515
Colour (base paint)	23,000	* * * *	6.01	138,230
Catalyst (colour)	No data	* * * *	No data	No data
Varnish (base paint)	8,000	* * * *	5.4	43,200
Catalyst (varnish)	2,000	* * * *	9.01	18,020
Application solvents	6,000	* * * *	2.40	14,400
Isopropyl alcohol	500	Various	3.00	1,500
Distilled water	450,000	Varios	16.82 €/m^3	7,569
Totals	497,020	—	—	272,614

2.2. *Auxiliary materials and energy consumption*

The main auxiliary materials used at DECAYPRINT, SA, and their annual consumption (for 1997), along with the purchase price, are shown in *Table 4.*

The cleaning solvent for the equipment is (brand).

Table 4

Auxiliary material	Annual consumption	Unit price (€)	Cost/year (€/year)
Equipment cleaning solvent	23,000 l	0.6	13,800
Synthetic oil (to heat the kiln)	200 l	6.01	1,202
Propane (polypropylene surface activate)	2.5 cylinders	9.01	22.5
Natural gas (kiln burner)	91,060 m^3	0.27	24,586
Electricity	374,244 kWh	0.09	33,682
Mains water supply (booths)	50 m^3	1.35	67.5
Brown paper	5,000 u.	0.24	1,200
Polishing paste	500 u.	1.2	600
Labels	700,000 u.	0.03	21,000
Bubble-wrap to wrap the end product	50,000 u.	0.18	9,000
Cardboard boxes for the end product	2,000 u.	6.6	13,200
Antimoistering agent (rinsing water)	150 l	5.28	792
Flocculant (water in booths)	1.5 kg/booth/day	3.3	6,593
Biocide (water in booths)	2 kg/booth/day	1.02	2,717
Cloths to clean parts	700 kg	1.8	1,260
Totals	—	—	129,722

With all this, the total annual cost to the company in consumption, of raw and auxiliary materials, water and energy, is approximately 420,000 €.

3. Description of the facility, the manufacturing processes and the activities diagnosed

3.1. *Description of the facility*

3.1.1. General description

DECAYPRINT, SA, covers an area of approximately 2,200 m^2, divided between the main manufacturing shop, the plastic parts warehouse, the storage areas for paints and auxiliary material and the yard.

3.1.2. The manufacturing shop

The manufacturing shop, which covers 1,400 m^2, houses the two continuous paint lines, the static booth, the zones meant for sticking adhesives on the painted plastic, the areas of polishing and hand-cleaning of the parts before they are painted, the offices, the quality control area, the mixing shop, the sanitary services a compresser and a gas kiln.

The different working areas are marked by yellow lines, limits which are respected by the staff that work there. The shop is also used as a warehouse for parts awaiting distribution, when this is not done directly they exit the process. The impression is that all available space is occupied.

In some areas of the shop, particulary the area where parts are cleaned with solvent by hand, there is a strong smell of solvents.

The two paint lines are almost completely closed. The shop has six chimneys, one per paint booth, and three air outlets to the outside of the shop from line 1 and four more from line 2. These outlets, which each have a 1/4 CV extractor fan, ventilate the lines' drying areas, at the exit of the paint booths and the polymerization kilns.

3.1.3. The warehouse for parts to be painted

About 150 metres from the plant, DECAYPRINT, SA has a warehouse for the plastic parts to be painted (new parts and rejects that need repainting)

New parts are stored, as they arrive, on pallets, shrink-wrapped and in cardborad boxes, half way along the warehouse nearest the main entrance. Sometimes, the parts arrive in metal cages.

The parts to be painted are wrapped in polyethylene and polypropylene film. In the warehouse, they are taken out of the cardboard box and placed in plastic boxes, each with a capacity of 800 litres, to be taken to production.

Rejects, if there is a rush on, are polished in a part of the warehouse near the door. These parts are stored separated by a corridor from the parts which have still to pass through the paint lines.

Some clients allow the painted parts to be returned in the box they came in, which means they are reused. The other cardboard boxes are thrown away. The plastic film the parts were wrapped in is also thrown away when it is taken off.

The warehouse is run by the manager, and two other workers. There is a warehouse management procedure established. The exit of stored material is carried out according to work orders and through outside transport hired by the company.

If any of the parts are found to be in less than perfect condition —scratched, broken etc.—, the warehouse staff withdraw it and return it to the supplier.

3.1.4. The paint storage area and changing rooms

Next to the main shop —manufacturing—, is a platform on the same level, opposite the main entrance, which houses the changing rooms and the paint and auxiliary materials warehouse. Both areas are lines of prefabricated metal modules, about 40 m^3 each, closed and in a line.

The paints warehouse, as it is specially insulated, keeps the paint inside at the correct temperature, in compliance with legislation on paint storage, and ensures its properties are maintained.

3.1.5. The yard and the tool and waste storage areas

In the yard, which is approximately a metre lower than the shop and is open, we find the car park, the waste storage area and the tool storage area. This area is not paved, and is shared by neighbouring firms.

Waste is stored in the open, in an open ordinary refuse container. A large amount of waste, which does not fit in the container, is piled up next to it, on the ground. This consists mostly of cardborad and wooden pallets, along with paint crusts from the booths and other waste products.

Next to the piled-up waste, the company stores, also in the open, tools for hanging the parts on the paint lines.

3.2. *Description of equipment*

3.2.1. The paint lines

The company has two paint lines.

3.2.1.1. *Paint line 1*

Paint line 1, which is the older of the two, consists of the following elements:

- Isopropylene cleaning area, preparation and hanging of the parts.
- Wash area - using distilled water and humectant.
- Drying kiln at 50 ºC.
- Compressed air drying unit.
- Unit for blasting with de-ionized air to remove static electricity from the plastic.
- Paint booth 1.
- Baking kiln at 80 ºC, duration 25-30 minutes.
- Checking room.
- Paint booth 2.
- Transit area for parts heading for booth 3.
- Paint booth 3.
- Polymerization kiln: 70-80 ºC, parts pass through at a speed of 0.5 m/min.
- Final checking area.

3.2.1.2. *Paint line 2*

Line 2, which is almost completely enclosed, consists of:

- Hanging area, in the area next to it, the parts are cleaned by hand with isopropylene.
- Paint booth 1.
- A transit area for parts heading for booth 2.
- Paint booth 2. An automatic varnish and solvent mixer has been added onto this booth; the advantage of this is that there is never any unused varnish left over, and less waste is generated in the painting operations.
- A transit area for parts heading for the polymerization kiln.
- Polymerization kiln: 70-80 ºC, parts pass through at a speed of 0.4 m/min.
- Final checking area.

3.2.2. Paint booths

The company has two different types of paint booth; the paint line booths and the static booth.

3.2.2.1. *Paint line booths*

The paint booths are pressurised with water curtains, and have prefilters, top filters (upper filter) and a grid filter (behind the water curtains).

The booths in line 1 use 4 m^3 water/booth, whilst those in line 2 use 3 m^3 water/booth.

Each booth has dry filters to filter the outside air. The top filters are changed every 6 months, while the prefilters (they blow out air) are changed every 3 months, as they get very dusty. The grid filters are changed every day, as per regulations. Two people from an outside firm clean the booths every night.

3.2.2.2. *The static booth*

The static booth is dry (no water curtain), and is equipped with filters for both incoming and outgoing air.

3.2.3. ***The mixing and painting equipment***

The company has a single automatic mixing unit, which is used to prepare the varnish applied in booth 2 of line 2.

The painting equipment consists of:

6 spray pumps.

6 spray guns.

Compressed air heaters.

3.2.3.1. *The mixing unit*

The company has one mixing unit, which is used to prepare the varnish applied in booth 2 of line 2. Currently, this unit is being tested. The company is considering using automatic mixing units for priming and painting.

The unit currently in use is a (brand) [redacted], "[redacted]", which doses and mixes two components.

The use of automatic mixing units has 3 main advantages:

- There is never too much paint mixed, which means lower consumption, less waste and lower management costs.
- The consumption of cleaning solvents is reduced (as opposed to cleaning solvent consumption when prepared manually, which involves cleaning the mixing pots, etc.), as are the costs of solvent and waste solvent management.
- The quality of the painting is uniform because the mix can be controlled.

3.2.3.2. *The spraying and painting units*

The 001.085-DP double membrane pumps feed paint, primer or varnish mixed with compressed air to the guns. The guns are HVLP-type[46], by [redacted], which use warm compressed air (equipped with air heaters), and they work at a pressure of 5-6 kg/cm^2 and a flow of 75 m/min.

[46] HLVP is the acronym of High Volume Low Pressure.

3.2.4. *The kilns*

The shop has four kilns:

- The drying kiln for parts washed in line 1.
  This kiln works at 50 ºC.
- The line 1 baking kiln (dries the primer).
  This kiln works at 80 ºC, and the parts are inside for 25-30 minutes.
- The line 1 polymerization kiln.
  This kiln works at 70-80 ºC, parts pass through at a speed of 0.5 m/min.
- The line 2 polymerization kiln.
  This kiln works at 70-80 ºC, parts pass through at a speed of 0.4 m/min.

The polymerization kilns each have an air outlet to the outside of the shop. So do the baking and drying kilns.

The line 1 primer kiln and the line 2 polymerization kilns have air filters. The rest do not.

The heating systems for the four kilns in the shop run on thermal oil heated by natural gas burners. The oil is synthetic and is analysed every year. The circuit is periodically drained: this generates a drum of waste oil a year at the most, that is, about 200 litres/year. In 1995, the oil was changed completely (about 2,225 kg), as it was vegetable oil. The change to synthetic oil brought about an improvement in the heat produced. The oil was removed by . The 2 booth cleaners also switch on the thermal oil heating system, 2 hours before the day's work begins. It is believed that the oil in the circuit will need to be changed every 4 or 5 years.

3.3. *Detailed description of the production process*

The production process consists of the following stages:

Reception/parts and paint storage

↓

Paint quality control and part treatment testing

↓

Paint preparation

↓

Preparation of surfaces to be painted

↓

Painting

↓

Drying and polymerization of paint applied

↓

Final quality check of finished parts

3.3.1. *Reception and storage of parts to be painted and paints*

3.3.1.1. *Reception and storage of parts to be painted*

The parts to be painted enter the plant and are stored in their own warehouse. Some parts, chosen at random, undergo quality control before being accepted. The rest undergo inspection whilst they are being handled during the production process.

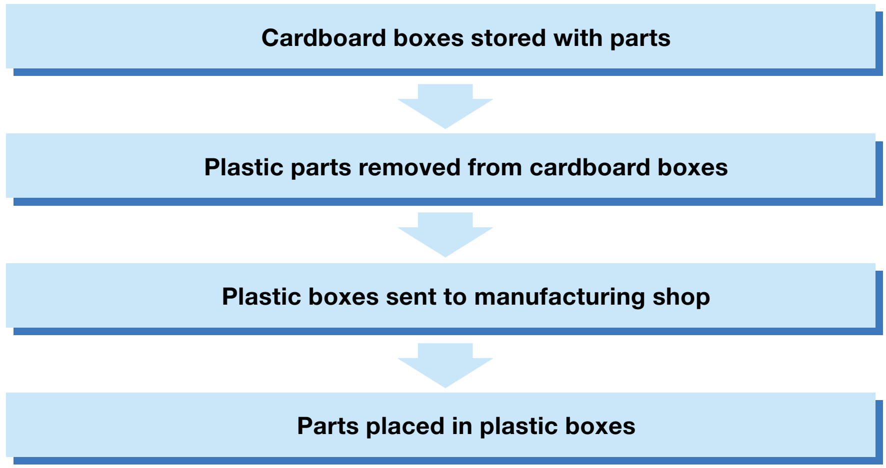
The parts come from the client, as mentioned previously, wrapped in polypropylene film, in shrink-wrapped cardboard boxes on pallets or in metal cages. In the warehouse, they are removed from the cardboard boxes and placed in plastic boxes which measure about 0.8 m^3. Approximately 50% of the cardboard boxes and wooden pallets are returned to the clients with the painted parts. The rest are managed as ordinary refuse or taken by a scrap merchant. The plastic boxes belong to DECAYPRINT, SA, and are used repeatedly. The sequence is explained below in a flow chart:

Plastic parts to be painted enter plant in cardboard boxes

↓

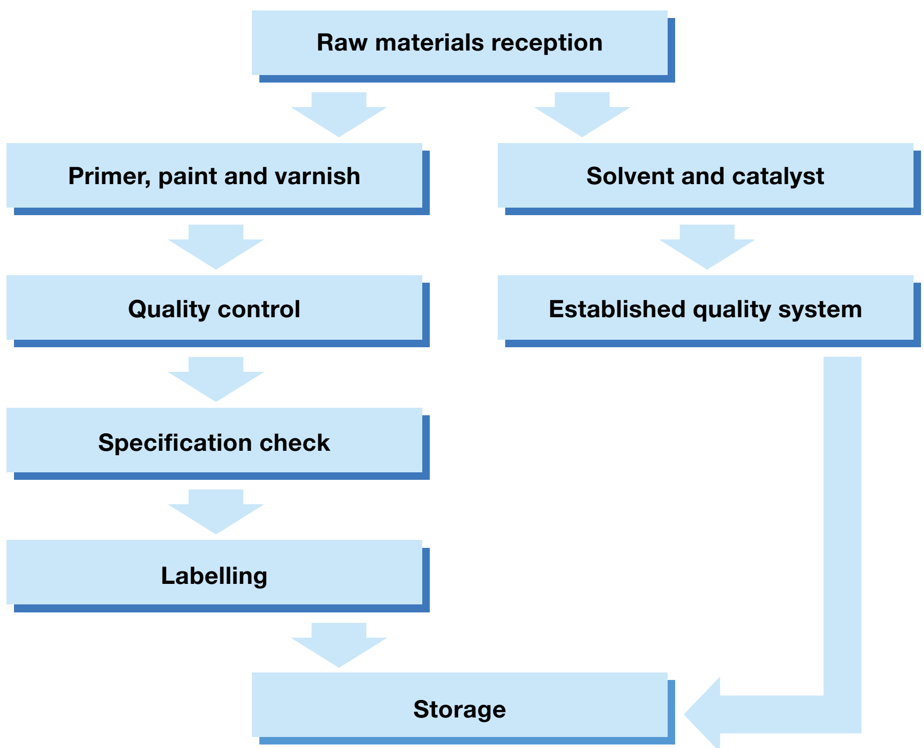
Quality control of plastic parts

↓



3.3.1.2. *Raw materials reception and storage*

All the paints (primer, varnish and colour paint) are of the so-called 2-component type (catalyst and colour come separately) and arrive in pots of between 4 and 25 kg (eg. The catalyst comes in 4 kg pots and the paint usually comes in 25 kg pots).



The paint pots come in one at a time and are stored in containers-prefab modules measuring 40 m^3, as described in the corresponding section, opposite the paint entrance to the manufacturing shop. These containers, as mentioned previously, are equipped to maintain the paint at the right temperature. If the paint pots are small or a lot arrive at once, they come shrink-wrapped on pallets.

As for the solvents and catalysts, they are not checked on arrival as there is a system of quality control established with the supplier; however, despite this, they are inspected during use. They are also stored in the container-modules.

When a work order is received, the necessary raw material is taken from the warehouse and taken to the mixing room.

Table 5, below, contains technical information on the various raw materials consumed by the company and their principal components:

Table 5

Raw material	Primary components	Principal hazardous components
Primer	Organic non-chlorinated solvents	Xylene, *n*-butyl acetate cyclohexanone
Varnish	Organic non-chlorinated solvents	Ethylene acetate, methyl-ethyl-ketone, ethylbenzene, isobutyl acetate, xylene, toluene
Colour paint	Polyester with non-chlorinated solvents	Xylene, ethylbenzene, butanone, butane
Catalyst	Organic non-chlorinated solvents	1-methyl-2methoxyethylene acetate, xylene, ethylbenzene, hexamethylene 1,6-diisocyanate

3.3.2. *Paint batch quality control, part treatment testing*

New batches of paint are checked to ensure they comply with quality standards (colour, viscosity, etc.) as specified in the company's paint quality control procedure. The quality control tests are carried out in the static booth.

Any paints which do not pass these tests are returned to the client. Paints that have passed their best-before date or are deteriorated, through the fault of the company, are marked and managed externally, either by the supplier or as a waste product *(see also point 3.4.2 of this report).*

Plastic parts that have received no treatment whatsoever, are sometimes tested to determine the best way to achieve the result required by the client. These tests are also carried out in the static booth.

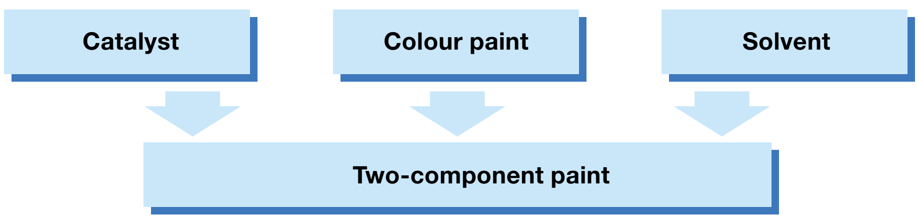
All the plastic parts are checked as they are hung on the assembly line, and if they are defective, they are withdrawn before painting and are managed externally. During their passage along the paint line, the supervisor in each booth also checks that the parts are in perfect condition before they are painted.

3.3.3. *Paint preparation*

Almost all mixing is done manually. In manual mixes, 3 to 4 kilos of paint are prepared, slightly more than in necessary so as not to run out of paint before the process is finished. The paint left over is thrown away, catalysed (dry), in the ordinary refuse.

As has already been mentioned, the varnishes to be applied in booth 2 of line 2 are mixed in an automatic unit, brand , right next to the booth. The unit prepares the mixture as it is needed, which avoids there being any left over. The company is considering using these automatic units to prepare the paints and primers too.

The paint preparation process is summarised on the flow chart below:



3.3.4. *Surface preparation*

Approximately 30% of the parts to be painted arrive with rough edges which have to be smoothed before they are placed on the paint line. Smoothing is done by hand, with glasspaper, in a specially designated area of the manufacturing shop.

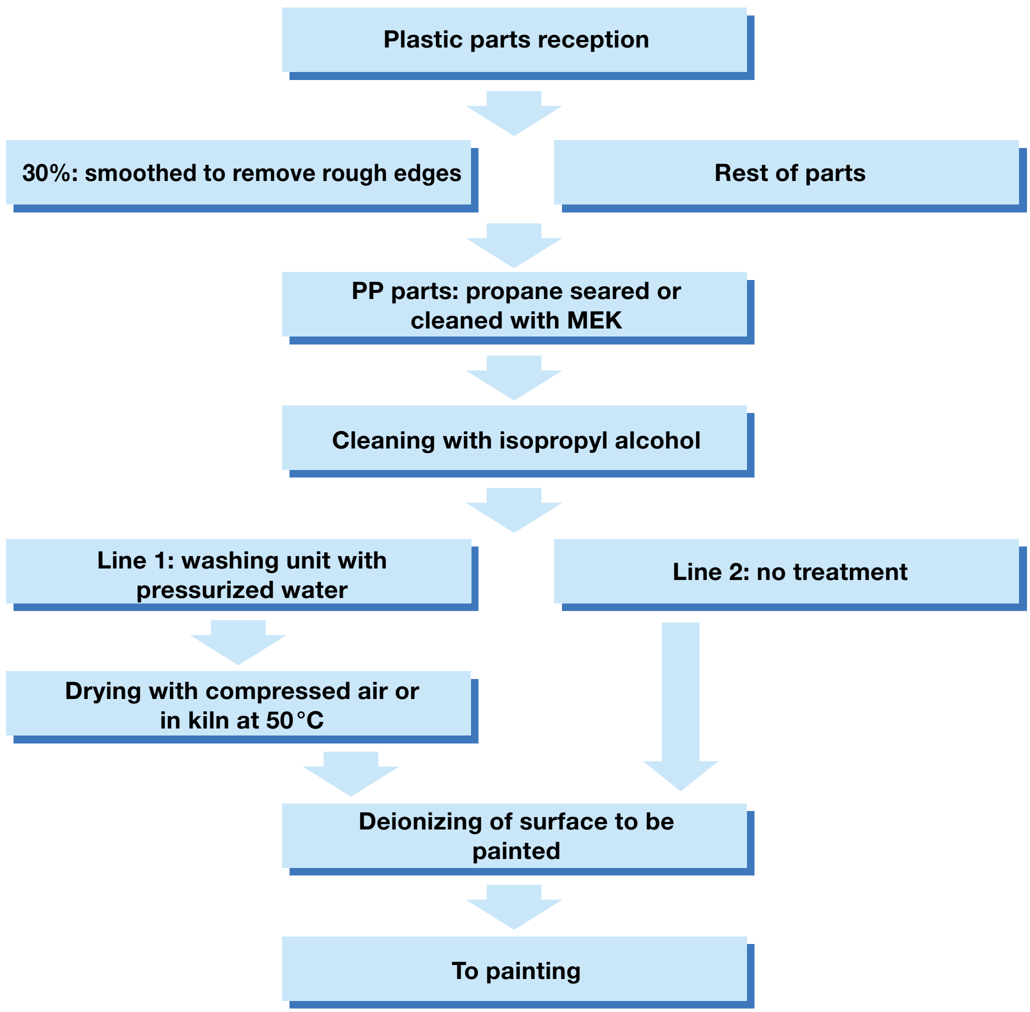
If the part to be painted is made of PP, it is seared with a propane flame (activated) or cleaned with MEK (methylethyl ketone). These two pretreatments change the polarity of the plastic, and increase the surface tension to adapt it to that of the paint.

Independently of the material, the outer surface of all parts is cleaned with isopropyl alcohol. The parts are then hung on the production lines.

On line 1, the parts go through a continuous washing unit with pressurized water (demineralized water and antimoistering agent). Next, the parts are dried either with compressed air or in an kiln at 50 °C. The company is currently considering eliminating this washing stage. Once dried, the parts are blown with deionized air to remove the static electricity from the surface of the plastic.

No pretreatment of parts is carried out on line 2.

The process can be summarised as follows:



3.3.5. *Painting*

The paint is applied in 6 booths: one independent static booth for very short series, 3 booths in line 1 and 2 in line 2.

After pretreatment, the parts go through the paint booths depending on the line:

- Line 1:
  - —booth 1: 70% primer and 30% colour only.
    (After the primer, parts are baked in booth 1 at 80 ºC, for 25-30 minutes, flaws are smoothed and finally, the colour is applied).
  - —booth 2: 100% colour.
  - —booth 3: 95% varnish (2 coats) and 5% colour.
- Line 2:
  - —booth 1: 100% colour.
  - —booth 2: 100% varnish (2 coats).

Paint is applied by hand, with HVLP-type spray guns which run on compressed air. The gun is attached to the paint tank by a hose. Control of the process is carried out during painting, and normally the paint manufacturer's instructions are followed.

Internal painting management systems have been incorporated, as there are many changes of colour. In any case, an attempt is made to follow criteria in the use of colours. In addition, there is a static booth for very short series.

Painting equipment is cleaned with every change of colour, at the end of each working day and whenever it is to be inactive for longer than half an hour, so that the paint does not catalyze and damage the equipment. Cleaning is carried out when the painting operation is complete.

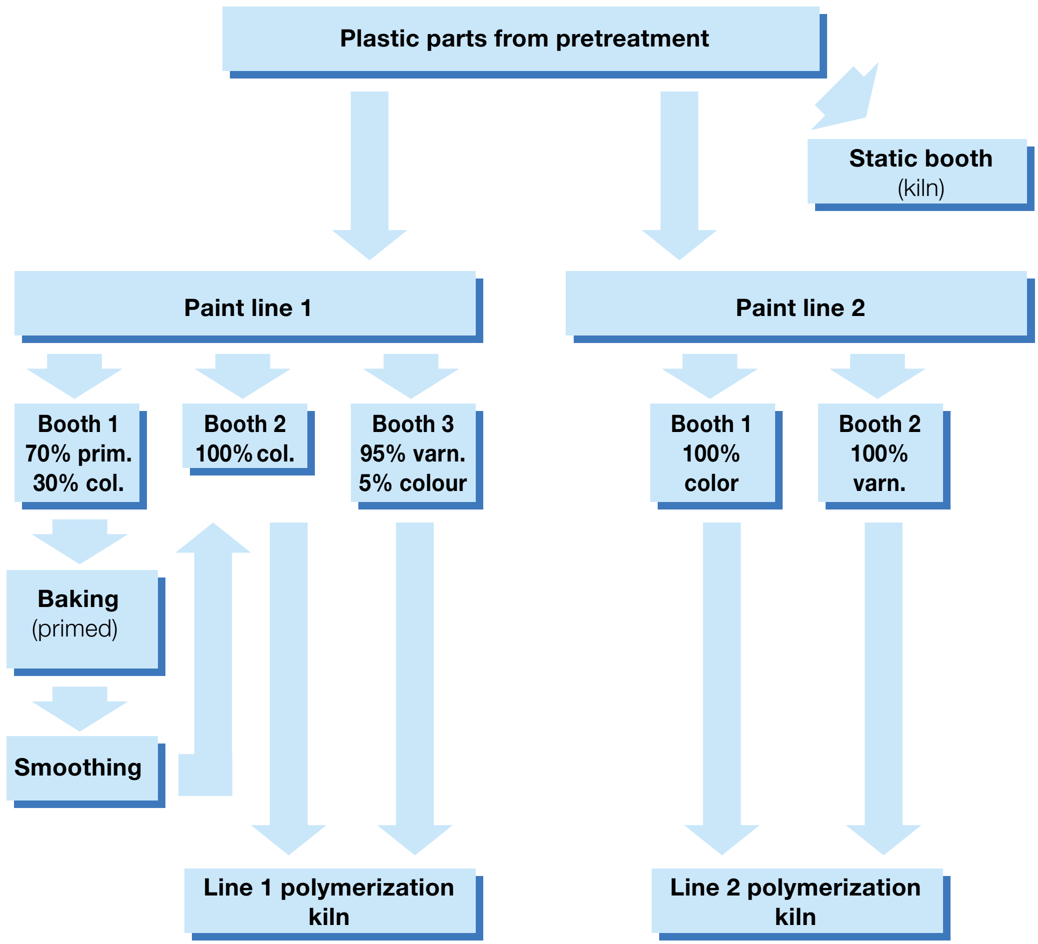
3.3.6. *Drying and polymerization of the paint applied*

Once painted, the parts are subjected to preevaporation at room temperature as they pass along the lines between booths, or between booth and kiln. In the case of the primer applied on line 1, the parts are dried in the line's baking kiln.

Parts coming from booth 2 of line 2 and booth 3 of line 1 go into the polymerization kiln of their respective lines, for about 45 minutes at 70-80 ºC. They go through the kiln on line 1 at a speed of 0.5 m/min, and through the one on line 2 at 0.4 m/min.

Parts are also dried in the static booth, as it incorporates a kiln.

These two sequences can be summarised in the following flow chart:



3.3.7. *Quality control of finished parts, quality adjustments*

On leaving the polymerization kiln, the parts are inspected; if flaws are found, the parts are smoothed with water and a smoothing machine. 10% of the parts inspected have flaws, which means they must be smoothed completely. This removes the shine, so they have to be repainted. 1.5% of the parts are considered non-profitable waste and are taken away by a plastics recovery firm.

Finished parts are labelled and placed in cardboard boxes (50% of the total), plastic containers, trolleys with a plastic lid or metal bars. All painted parts are wrapped in bubble wrap (foaming plastic).

3.4. *Stocks management*

3.4.1. *Management of parts to be painted*

The warehouse for unpainted parts is run by 1 manager and 2 other workers. There is an established warehouse management system.

When an unpainted plastic part is damaged (scratched, broken, etc.) it is withdrawn by an authorised plastics management firm, .

The exit of stored material is carried out according to work orders, through outside transport hired by the company.

3.4.2. *Raw materials management*

The pots of raw materials are stored in containers of about 40 m^3 in size, outside the manufacturing shop. Instructions for storage are available. The company also has instructions available for the control of raw materials. The actual procedure followed is: reception-quality control-validation-labelling-storage.

The process and cleaning solvents are stored in an identical container. Inventory is taken on a quarterly basis of the whole warehouse to avoid the materials passing their best-before date.

With regard to materials which have passed their best-before date (paints: < 2%, 1,000 kg/year), the supplier is consulted to establish whether they can be used, if not, they are treated as waste or used to paint the premises. In no case are they used if they are not in a fit state. There are also instructions regarding the treatment of paints and solvents which are unfit. Dirty solvents may represent between 3,000 and 4,000 l/year.

3.4.3. *Auxiliary materials management*

Auxiliary materials (glasspaper, cloths, gloves, flocculant and germicide for the water in the paint booths, etc.) are stored in a special warehouse, which is also a 40 m^3 container outside the manufacturing shop.

The factory contains no paints, solvents or other auxiliary materials except those for immediate use.

3.5. *Good housekeeping practices*

As has already been stated, DECAYPRINT, SA, has implemented a UNE-EN-ISO-9002-quality management system.

The certification manuals and procedures, detail[47] a whole series of professional operations with environmental effects on the operations of paint application; spray gun maintenance and cleaning; mixing; handling primed parts in the checking booth, and conservation and cleaning of the water curtains in the paint booths.

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[47] The original MOED detailed these practices. They are not included in this copy.

4. Numbering and description of waste flows generated in the different stages of the process. Causes of generation, current management

4.1. *Waste*

Below, the waste[48] generated by DECAYPRINT, SA, is classified and details are given of the amount generated annually, classified as follows:

- Special waste
- Non special waste
- Inert waste

Special waste: **Table 6**

Waste	Amount generated annually	Management
Hardened paints and varnishes	No data	Ordinary refuse
Paints and varnishes which contain non-halogenated solvents • Spoilt paint • Sub-stardard paint • Paint past best-before date	<1,000 kg	Supplier …… Supplier ……
Cleaning cloths soiled with polypropylene and MEK	700 kg	Ordinary refuse
Non-halogenated solvents with residues of paint or varnish (cleaning of equipment)	3,000-4,000 l	……………
Sub-standard or spolit solvents or catalysts	500-1,000 kg	Supplier ………….
Dirty filters from booths	4,000 u.	Ordinary refuse
Dirty metal paint pots	3,000 u.	Ordinary refuse
Heat-transmitting synthetic oils	200 l	……………

[48] The classification of waste in this example corresponds to legislation on waste currently in force in the area where DECAYPRINT, SA is located:

a) Special waste: all waste includes in the area of application of Directive 91/689/EC, of 12 December, which defines what is meant by hazardous waste.

b) Non-special waste: all waste not classified as special or inert.

c) Inert waste: waste which, once left in a tip, undergoes no significant physical, chemical or biological changes and fulfills the leaching criteria established in regulations.

Non-special waste:

Waste	Amount generated annually	Management
Office paper	No data	Ordinary refuse
Wooden pallets	No data	Ordinary refuse

Inert waste:

Table 7

Waste	Amount generated annually	Management
Polypropylene film (packaging) Shrink-wrap plastic (packaging)	No data	Ordinary refuse
Wooden pallets	No data	Ordinary refuse, scrap merchant
Cardboard boxes	No data	Ordinary refuse, scrap merchant
Toners	No data	Ordinary refuse
Sub-standard plastic parts	2,000 u.	Returned to supplier
Damaged unpainted plastic parts	6,000 u.	....

4.2. *Waste waters*

Table 8 shows the types of waste water generated by the company, the annual amount generated of each type, its destination and management.

Table 8

Source of dumping	Amount dumped m³	Pollutant content of waste	Dumping frequency	Manager
Toilets/domestic	1,100	Faecal, soap	Continuous	—
Parts wash	4-4.5	Antimoistering agent	2-3 times/year	—
Paint booths	17	Paint, flocculant	2-3 times/year	....

The company generates the following industrial waste waters:

- Water from parts wash on line 1 containing distilled water and antimoistering agent. There are about 4-4.5 m^3 of water, which is dumped 2 or 3 times a year.
- Water from the paint booths on line 1. Each of the 3 booths on line 1 holds 3 m^3 of water, which is changed 2 or 3 times a year.
- Water from the paint booths on line 2; in this case, each of the 2 booths on line 2 holds 4 m^3 of water, which is changed 2 or 3 times a year.

4.3. *Emissions into the atmosphere*

The company has 15 specific points of emission: 12 emit outside the shop and 3 into the air inside. The 15 points have different outlets (chimneys or pipes). The 15 points are listed below:

- The 6 chimneys of the 6 paint booths.
- The 5 air outlets from the the transit areas of the parts on the lines (3 on line 1 and 2 on line 2).
- The 4 air outlets from the 4 kilns (1 on line 2 and 3 on line 1).

The chimneys of the paint booths emit solvents, spray paint and a little steam. The air outlets in the transit-preevaporation areas emit solvents. Finally, the air outlets of the 4 kilns emit solvents.

The table below summarises the emission points on line1, their characteristics and the substances they emit:

Table 9

Source of emission	Substances emitted	Extraction capacity (CV)	Receiving medium
Drying kiln	Solvents	15	Recirculated air
Booth 1	Solvents Spray paint Steam	7.5	Outside air
Baking kiln	Solvents	9	Outside air
Booth 2	Solvents Spray paint Steam	7.5	Outside air
Preevaporation area	Solvents	0.25	Outside air
Booth 3	Solvents Spray paint Steam	7,5	Outside air
Preevaporation area	Solvents	0.25	Outside air
Polymerization kiln	Solvents	9	Outside air

The table below details the emission points on line 2, their characteristics and the substances they emit:

Table 10

Source of emission	Substances emitted	Extraction capacity (CV)	Receiving medium
Booth 1	Solvents Spray paint Steam	7.5	Outside air
Preevaporation area	Solvents	0.25	Outside air
Booth 2	Solvents Spray paint Steam	7.5	Outside air
Preevaporation area	Solvents	0.25	Outside air
Preevaporation area	Solvents	0.25	Outside air
Polymerization kiln	Solvents	40	Outside air

Table 11 details the emission points external to the lines:

Table 11

Source of emission	Substances emitted	Extraction capacity (CV)	Receiving medium
Static booth	Solvents Spray paint	5	Outside air
Gas burner		?	Outside air

Finally, the company has 2 diffused emission points (with unchannelled emissions or conducted by a chimney). *Table 12* shows these emission points:

Table 12

Source of emission	Substances emitted	Receiving medium
Cleaning with isopropyl alcohol	Isopropyl alcohol	Inside air
Cleaning with MEK	MEK	Inside air

4.4. *Generation of pollutants by area or activity*

Table 13 shows the different pollutants generated by each stage of the process.

Table 13

Stage of process	Action	Pollutants generated	Destination of pollutants
Parts reception	Unpacking of parts to be painted Unpacking of pots of paint	Cardboard boxes Wooden pallets Shrink wrap Polypropylene or polythene film Metal cages Broken plastic boxes Substandard plastic parts Wooden pallets Shrunken wrap	Clients (approx. 50%), rest to ordinary refuse Clients (approx. 50%), rest to ordinary refuse Ordinary refuse Ordinary refuse Return to clients Ordinary refuse Supplier Clients (approx. 50%), rest to ordinary refuse Ordinary refuse
Quality control	Plastic parts quality control Paint quality control	Substandard plastic parts Substandard paint	Return to supplier Return to supplier
Storage	—	Materials past best-before date: paints (includes primer, colour and varnish) Spoilt plastic parts	Establish fitness for use with supplier and use or external management at**** External management at****
Mix preparation (paint)	Mixing of different components	Spoilt paint (not past best-before-date) Substardard or spoilt solvent and catalysts Dirty paint pots Leftover paint (dry) Solvent emission (VOCS)	Supplier or external management at**** Supplier or external management**** Ordinary refuse Ordinary rerfuse Inside air
Part preparation	Smoothing of rough edges (30% of parts) Cleaning and activation with propane Cleaning and activation with methyl-ethyl-ketone (MEK) Cleaning by hand with isoprophyl alcohol	Plastic residue Emission of combustion gases Dirty packs, Cloths impregnated with MEK VOC solvent emission Dirt packs Cloths impregnated with isoprophyl Alcohol emission	Ordinary refuse Atmosphere Return to supplier Ordinary refuse Inside air Return to supplier Ordinary refuse Inside air
Hanging	Visual inspection	Defective plastic parts	Supplier or external management at****

(Continue)

Line1: partswash	Continuous cleaning with demineralized water + antimoistering	Waste waters with antimoistering agent	Sewer
Line 1: part drying	Drying with compresed air or drying at 50° in an kiln	Steam emission	Outside air
Deionization of parts	Blowing with deionoized air	None	—
Line 1: painting	Booth 1: 70% primer, 30% colour Both 2: 100% colour Booth 3: 95% varnish (2 coats) and colour	Dirty water from booths Hardened paint and varnish Air prefilters, *Top* filters and Grid filters Leftover primer, paint VOC solvent emission Dirty water from booths Hardened paint and varnish Air prefilters, *Top* filters and Grid filters Paint VOC solvent emission Dirty water from booths Hardened paint and varnish Air prefilters, *Top* filters and Grid filters Paint and varnish VOC solvent emission	**** Ordinary refuse Ordinary refuse Ordinary refuse Outside air **** Ordinary refuse Ordinary refuse Ordinary refuse Outside air **** Ordinary refuse Ordinary refuse Ordinary refuse Outside air
Line 1: Preparation for painting following priming (Booth 1)	Baking at 80 °C (after primer and before colour) Smoothing of flaws after baking	VOC and exhaust emission Smoothed materials	Outside air Ordinary refuse
Line 2: painting	Booth 1: 100% colour Booth 2: 100% varnish (2 coats)	Dirty water from booths Hardened paint Air prefilters, *Top* filters and Grid filters Leftover paint, varnish VOC solvent emission Dirty water from booths Hardened varnish Air prefilters, *Top* filters and Grid filters Leftover paint, varnish VOC solvent emission	**** Ordinary refuse Ordinary refuse Ordinary refuse Outside air **** Ordinary refuse Ordinary refuse Ordinary refuse Outside air
Static booth	Painting in short series	Dry filters VOC solvent emission	Ordinary refuse Outside air

(Continue)

Drying-polymerization	Preevaporation at room temperature Polimerization in kiln at 70-80 ^{o}C	Slight VOC solvent emission VOC and exhaust emission Synthetic thermal oil (draining) Kiln filters	Inside air Outside air **** Ordinary refuse
Retouching of finish *10% of parts; total polish, repainting* *1.5% of parts, broken*	Polishing with water Mechanical polishing	Dust from polished material Dust from polished material Broken parts	Ordinary refuse Ordinary refuse ****
Packaging	Labelling Bubble wrapping Boxing (50% of parts) 50% to containers, trolleys or baskets	Bits of label Bubble-wrap Broken boxes	Ordinary refuse Ordinary refuse Ordinary refuse
Cleaning of equipment and premises	Cleaning paint from guns, hoses, etc. Outside cleaning of paint from equipment Cleaning of equipment, floors, etc.	Dirty solvents containing paint Dirty cloths impregnated with solvent and paint Hardened paint and varnish VOC solvent emission Dirty solvents containing paint Dirty cloths impregnated with solvent and paint Hardened paint and varnish VOC solvent emission Dirty solvents containing paint Dirty cloths impregnated with solvent and paint Hardened paint and varnish VOC solvent emission	**** Ordinary refuse Ordinary resuse Outside air **** Ordinary refuse Ordinary refuse Outside air **** Ordinary refuse Ordinary refuse Outside air

4.5. *Management costs of pollutants generated*

Table 14 shows the environmental management costs for each of the pollutants for which reliable data are available. There are no data available for the other types of waste.

Table 14

Waste	Transport cost	Management cost	Total annual cost
Waste water from paint booths	1,502.5 € /year	1,202 € /year	2,704.5 €
Non-halogenated solvents	120.2 € /year	2,554.3 € /year	2.674,5 €
Paints and varnishes	18 € /year	450,75 € /year	468,75 €
Dirty drums	Included in management	9,015 € /year	9,015 €
Plastic waste	Included in management	Cost: 0.03 € /kg	Amounrt generated unknown
General waste	Included in management	5,108 €	5,108 €
Oils	Included in management	30 € / year	30 €
Totals	1,640.7 € /year	18,360 € /year (approx.)	20,000 € /year (approx.)

5. Description of the alternatives recommended and their technical and economic viability

Within the chapter on minimisation options, the following alternatives have been considered:

5.1. Reduction at source

- Process modification:
  —Raw materials that cause less pollution
  —Prior treatment of raw materials
  —Process modification
  —Equipment modification
  —Changes in production sequence
- Good housekeeping practices

5.2. Recovery and recycling

- In the company itself.
- Outside: sent to the supplier or reuse in another company.

For each alternative, and depending on the case, various minimisation options are proposed, as detailed below:

DESCRIPTION OF MINIMISATION ALTERNATIVES

Waste flow analysed:
Minimisation alternative:
Minimisation options: 1, 2, etc.
Other flows affected:

Raw materials affected:
Processes or products affected:
Possible savings in consumption of raw and auxiliary materials:
Possible reduction of pollutants:

Technical justification of each option:

—Testing of technology
—Effect on the quality of the process or product:
—Space required:
—Implementation period:
—Requirements for use:

Economic justification of each option (in €):

Expenses:
—Equipment:
—Installation:
—Engineering:
—Services:
—Start up:
—Value of equipment at the end of its useful life:
—Training:
—Raw materials:
—Pollutant management:
—Running:
—Maintenance:
—Others:

Income:
—Sale of existing equipment:
—Increase in product selling price:
—Increase in production:
—Sale and/or valuation of by-products:
—Saving on raw and auxiliary materials:
—Saving on pollutant management:

Pay-back period:

Let us consider the different minimisation alternatives identified in the case of DECAYPRINT, SA.

5.1. *Reduction at source*

5.1.1. *Process modification*

Raw materials that cause less pollution

In the specific case of DECAYPRINT, SA, when proposing alternatives with regard to the use of paint and the like, we find the following limiting factors:[49]

In the light of this, the recommendations regarding the use of paints include:

1. Agreeing with clients, within their means, the use of alternative paints that cause less pollution:
   - Using water-based paints, with a very low organic solvent content (< 10%).
   - Using paints with a high solid content and low organic solvent content (< 20%).
2. Continue to use paint which contain no lead or zinc chromate.
3. In paints with 2 components, continue to use catalysts with a very low isocyanate content.
4. In this same type of paint, continue to use polyester and polyurethane resins with low molecular weight and moderate viscosity.

[49] The original MOED specified the restrictions which have to be considered in putting forward options which are coherent with the company's quality.

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* Use of primer, paint and varnish which contain organic solvents, which emit volatile organic compounds (VOCs) into the atmosphere.
- *Minimisation alternative:* Use of paint with lower organic solvent content.

- *Minimisation option 1:* Use of water-based paint.

For plastic materials, paint with 2 components (where a polyol and a polyisocyanate are mixed and react) is the most suitable as, particularly at low temperatures, the properties of the film (especially its elasticity) adapt to the properties of the substrate.

Another advantage offered by this type of paint, when painting plastic, is that it shrinks at room temperature.

Finally, it must be said that the adherence of the 2-component system to most plastics is very good, and is also very resistant to chemical agents, light and the elements.

In fact, this paint technology is preferable for painting plastics, and systemes are used based on [redacted] raw materials, especially with [redacted] (polyisocyanate and polyol, respectively).

Amongst the options offered by this type of paint with regard to composition, it is possible to use a water-based variety, in which the polyols are in an aqueous medium. They mix and react with the polyisocyanates. In this case, drying is carried out from room temperature up to 130-140 ^{o}C and the finish is as good as or better than with solvent-based varieties.

For example, [redacted] offers a water-based polyurethane of 2 components, [redacted]. Other important brands also have water-based alternatives such as [redacted] and [redacted].

As there is a wide range of combinations of polyol and polyisocyanate for water-based paints for plastics, it is recommended that:

- For **water-based primers:** choose those with polyurethane polyols with hydrophilic or hydrophobic polyisocyanates. As the finish does not need to be particularly shiny, the two components can be mixed with traditional mixers.
- In the case of **water-based lacquers:** a polyacrylate-polyester and polyurethane polyols can be used with low-viscosity hydrophilic or hydrophobic polyisocyanates.
- For **transparent water-based varnishes:** they have identical properties and composition as solvent-based varnishes.
- Finally, for **finish paints (colour):** they should contain polyurethane polyols and polyacrylate-polyester combined with low-viscosity hydrophilic polyisocyanates.

To finish, we would like to point out that in the plastics painting sector 2-component water-based systems are in use at nearly all stages of painting. In some cases, moreover, the results are better than with traditional solvent-based systems.

• *Minimisation option 2:* Use of paint with a high solid content.

There are also alternatives with high solid contents for 2-component systems, which consequently have fewer organic solvents.

For example, a water-based primer or a water-based lacquer can be combined and, on top, a solvent-based transparent varnish with a high solid content.

All the most important brands market products of these characteristics. For instance, the range by is particularly appropriate in the case of DECAYPRINT, SA, as it gives a more flexible finish and enables the plastic to be shaped. Within the same range of paints, there is also a varnish with high solid content, called .

• *Other flows affected:* The cleaning with solvents of tools and equipment and the cleaning with solvents of empty paint pots are the most important, the loss of raw materials through evaporation (the solvent in an open pot of paint evaporates, this can be 25-75% of the amount in the pot).

• *Raw materials affected:* Primer, paint, varnish, cleaning solvents.

• *Processes or products affected:* In the case of water-based applications, the facility where the paint is applied must be modified through the use of special equipment called made by , which is installed between the gun and the paint tank. The cost per unit is 9,015 €.

• *Possible saving in the consumption of raw and auxiliary materials:* If we count the approximate loss through evaporation as 5% from open pots and containers, at the end of the year we can save 2,150 kg of raw materials that contain solvents. At an average cost of 7,2 €/kg, this would mean an annual saving of 15,506 €.

• *Possible reduction of pollutants:* In the case of water-based paint, the percentage of solvent can drop from 80% to a maximum of 10%. For paint with a high solid content, the maximim percentage of solvent would be 20%. Consequently, the VOC values would be be reduced, a decrease of 88% of these compounds in the case of water-based paints and 75% for paints with a high solid content.

• *Technical justification of each option:*

—*Testing of technology:* Both options have been tested and proved and are on the market amongst the most important paint manufacturers.

—*Effect on the quality of the process or product:* None. In some cases, the finish is even better.

—*Space required:* The unit which should be used along with water-based paints is very compact, it measures about 0.10 m.

—*Implementation period:* Immediate, once the intermediate units are installed.

—*Requirements for use:* No special training or knowledge is required.

- *Economic justification of each option (in €):*

Expenses:
—*Equipment: 9,015 €* (unit for water-based paint.)
—*Installation:*
—*Engineering:*
—*Services:*
—*Start up:*
—*Value of equipment at the end of its useful life:*
—*Training:*
—*Raw materials:*
—*Pollutant management:*
—*Running:*
—*Maintenance:*
—*Others:*

Income:
—*Saving on resources:*
—*Sale of existing equipment:*
—*Increase in product selling price:*
—*Increase in production:*
—*Sale and/or valuation of by-products:*
—*Saving on raw and auxiliary materials:* The cost of this type of paint (water-based or with high solid content) may be between 3 and 5 times more expensive than the paint used now. Therefore consumption costs will increase.
—*Saving on pollutant management:* Cannot be calculated at the present time.
—*Pay-back period:* Given the current high cost of alternative paint, far higher than that of the paint currently in use, that an investment must be made in equipment that enables water-based paint to be used and that the company has no pollutant management costs there will probably be no pay-back period for the investment.

Prior treatment of raw materials

DECAYPRINT, SA, must adjust the viscosity of the paint to be applied depending on the room temperature and the humidity. This adjustment, as has already been mentioned, is made by adding a certain amount of solvent to the paint in question, until the desired viscosity is obtained. In this respect, the following is recommended:

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* The cleaning of equipment and elements used in painting which generates dirty solvent.

• *Minimisation alternative:* The reuse of dirty solvents in the reformulation of raw materials.

• Minimisation options: Every time equipment or facilties are cleaned with solvent, reuse the dirty solvent to adjust the viscosity in preparing a new batch of paint, provided the colour and quality allow.

• *Other flows affected:* Planning the stages of production.

• *Raw materials affected:* Paint and the like and solvents.

• *Processes or products affected:* Paint application.

• *Possible saving in the consumption of raw and auxiliary materials:* Formulation solvent.

• *Possible reduction of pollutants:* Fewer dirty cleaning solvents generated.

• *Technical justification of each option:*

—*Testing of technology:* This is an option already in use in many companies. In any case, it will be necessary to analyse whether the implementation of this alternative is compatible with the company's quality criteria.

—*Effect on the quality of the process or product:* Possible effects on the final quality of the product. Its viability must be established in each particular area of application.

—*Space required:* None.

—*Implementation period:* Once its viability has been established in each case, implementation is immediate.

—*Requirements for use:* It may be necessary to draw up written instructions or procedures so that the operator will know the correct way to execute the option in each particular case.

• *Economic justification of each option (in €):*

Expenses:

—*Equipment:*

—*Installation:*

—*Engineering:*

—*Services:*

—*Start up:*

—*Value of equipment at the end of its useful life :*

—*Training:*

—*Raw materials:*

—*Pollutant management:*

—*Running:*

—*Maintenance:*

—*Others:* Cost (depending on the amount reused) chargeable to analyse the viability of implementation in each particular case.

Income:

—Sale of existing equipment:

—Sale of existing equipment:

—Increase in product selling price:

—Increase in production:

—Sale and/or valuation of by-products:

—Saving on raw and auxiliary materials: a 10% reduction in the consumption of formulation solvent: 6,000 kg x 10% = 600 kg; 600 kg x 2.4 €/kg = 1,440 €/year.

—Saving on pollutant management: the same reduction in the amount of dirty solvent: 600 kg x 0.42 €/kg = 252 €/year.

Pay-back period: Given that this measure involves no extra cost, the pay-back period may be considered IMMEDIATE.

Process modification

As was seen in the detailed description of the activity (point 3.3.3 of this report), the preparation of the paint —and in particular of the desired colour— is carried out manually except in booth 2 of line 2, where varnish is applied. This manual preparation involves minor errors in the measurements of the various components which means minor adjustments must be made to correct them, until the desired colour is obtained.

The end result is the preparation of too much paint —to which the catalyst has already been added, and which will therefore last only a few hours before drying up—. It is estimated that this amount may be as much as 5-10% (depending on the expertise of the worker mixing the paint).

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* The preparation of paint before each application.
- *Minimisation alternative:* To minimise the amout of paint left over.
- *Minimisation options:* To acquire a mixing machine.
- *Other flows affected:* Cleaning empty paint pots.
- *Raw materials affected:* Primer, paint, catalyst and solvent.
- *Processes or products affected:* Paint preparation.
- *Possible saving in raw and auxiliary materials:* A 5 to 10% reduction in paint and solvent consumption, as no excess is generated. This may mean a reduction of approximately 1,500 kg of paint and primer and about 300 kg of solvent.
- *Possible reduction of pollutants:* these 1,800 kg become catalysed paint which ends up in the ordinary refuse bin.

• *Technical justification of each option:*

—*Testing of technolgy:* Mixing machines are widely in use in the sector. The company itself has one for preparing varnish.
—*Effect on the quality of the process or product:* None.
—*Space required:* Little, each machine takes up about 0.5 m^3.
—*Implementation period:* Once the machine has been acquired and the best place found for its installation, this can be completed in a morning, or less.
—*Requirements for use:* Specific instructions for use are required, which come with the machine.

• *Economic justification of each option (in €):*

Expenses:
—*Equipment: 2,404 € /unit. Total cost: 4,080 €*
—*Installation: 300.5 €*
—*Engineering:*
—*Services: 601€*
—*Start up:*
—*Value of equipment at the end of its useful life: 601 €*
—*Training:*
—*Raw materials:*
—*Pollutant management:*
—*Running:*
—*Maintenance:*
—*Others:*

Income:
—*Sale of existing equipment:*
—*Increase in product selling price:*
—*Increase in production:*
—*Sale and/or valuation of by-products:*
—*Saving in raw and auxiliary materials:* [1,500 kg (paint, primer and catalyst) x 7.21 € /kg = 10,815 €] + [300 kg (solvents) x 2.4 €/kg = 720 €] = 11,535 € /year.
—*Saving in pollutant management:* Catalysed paint is currently managed as ordinary refuse making this difficult to calculate.

Pay-back period: less than half a year.

Equipment modification

With regard to equipment, given that the use of liquid paints is essential, it can be said that, in general, the company is using the best technology on the present market:

- Paint booths with water curtains, a better alternative than dry filters as it allows the treatment and reuse of the water for 3-4 months.
- HVLP-type spray guns, better than conventional air guns; in fact it has been proven that applying paint with these HVLP *(High Volume Low Pressure)* guns has many advantages over traditional spray painting with compressed air:
  –The yield of effective paint application is 20% more than with pneumatic sprays, which means a saving in paint and solvents, and reduces VOC and particle emission through overspray during application;
  –Investment and energy costs are the same as those for traditional painting techniques;
  –Productivity levels remain the same, provided that the paint is applied in an even layer.
- Polymerization kilns with natural gas burners, as opposed to diesel oil burners, which pollute much more, or electric ones, which have excessive energy consumption for the economic viability of the process.

It is not appropriate, therefore, at this point to suggest any minimisation alternatives.

Changes in the production sequence

Painting is carried out following specific written work orders. When the job in question is finished, the equipment is cleaned to avoid colours mixing between applications. This cleaning, as we have already seen, generates dirty solvent which has to be managed as special waste. If the colours are very different, for example, light and dark colours, this cleaning with solvents must be more thorough, which implies greater consumption of product. Should the company always paint with the same colour, such frequent cleaning would be unnecessary, which would reduce the amount of dirty solvent.

Bearing this mind, planning the sequence of application of colours can reduce the number of times this “thorough” cleaning must be carried out and, consequently, the volume of waste generated.

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* The cleaning of painting equipment between applications of different colours.
- *Minimisation alternatives:* To reduce the amount of solvent used in cleaning.
- *Minimisation options:* Planning the sequence of colour application, so that light colours are applied first and the darker ones last.
- *Other flows affected:* Cleaning painting equipment.
- *Raw materials affected:* Cleaning solvent.

• *Processes or products affected:* Production planning. Given that the company works for third parties and has no products of its own, it is very often the case that colour application cannot be planned.

• *Possible saving in the comsumption of raw and auxiliary materials:* A reduction in cleaning solvent consumption.

• *Possible reduction of pollutants:* A reduction in the volume of waste dirty solvent and in solvent emissions into the atmosphere.

• *Technical justification of each option:*

—*Testing of technology:* Applying light colours first then dark ones is a generally accepted measure.
—*Effect on the quality of the process or product:* None.
—*Space required:* None.
—*Implementation period:* Sufficient to programme, each time, the order in which colours are to be applied.
—*Requirements for use:* It must be possible to programme. The fact that the company works for third parties will frequently make such planning difficult , as work is carried out as the client requests it.

• *Economic justification of each option (in €):*

Expenses:
—*Equipment:*
—*Installation:*
—*Engineering:*
—*Services:*
—*Start up:*
—*Value of equipment at the end of its useful life:*
—*Training:*
—*Raw materials:*
—*Pollutant management:*
—*Running:*
—*Maintenance:*
—*Others:*

Income:
—*Sale of existing equipment:*
—*Increase in product selling price:*
—*Increase in production:*
—*Sale and/or valuation of by-products:*
—*Saving in raw or auxiliary material: A saving in solvent consumption.*
—*Saving in pollutant management: A saving in dirty waste solvent management.*

Pay-back period: Given that the measure requires no investment and enables the company to save on raw materials and reduce pollutant management costs, this period is IMMEDIATE.

5.1.2. *Good Housekeeping Practices*

A fairly large chapter which offers the company many applications is that of Good Housekeeping Practices, since they simultaneously affect different waste flows.

In general, they are measures without any (at least direct) costs or at least with low costs for the economy, which have a very favourable effect on the reduction of raw material consumption and the generation of pollutants and substantially improve the control and overall management of certain company areas.

In addition, since the company is already in possession of the ISO-9002 certificate, a fair amount of these recommendations can be incorporated or integrated in the already existing processes or operating instructions.

The measures of Good Housekeeping Practices are arranged in accordance with their fields of aplication and divided into:

1. Storage of materials and waste.
2. Control of stock.
3. Material handling.
4. Plant operations.
5. Maintenance and care of premises.
6. Cleaning of equipment and premises.
7. Development and compliance with the operating procedures.
8. Waste segregation.

Below we will have a look at the set of proposals in accordance with this classification regarding the Good Housekeeping Practices directed at minimising pollutants:

1. *Storage of materials and waste*

Faulty storage of materials is a possible source of generating waste, such as the generation of products which have passed their best-before date, greater risk of spills, etc., which constitutes a hazard and risk for the workers themselves.

All processes developed by the company include the storage of raw materials, products, by-products and waste, and their transfer from one area of the plant to another. Proper storage is therefore an important opportunity for minimising waste.

The main general proposals which can be recommended include the following:

• Carrying out a standardised control of the state of impurity (greases, dust, etc.) of the parts received to be painted, in order to make sure they arrive in the cleanest state possible.

• Providing separate and suitable areas for storing raw materials, products, by-products and waste. These areas must be protected against inclement weather —light, rain, heat, etc.—

so as to avoid a deterioration of the container or the product itself, and must have a water-repellent concrete floor and a wastewater collection system independent of the general system. The area in question must be suitably marked and lit.

• Maintaining the order established in the storage area and the distances between materials to allow easy access to them and their inspection. Moreover, the distances between incompatible chemical products must be maintained. The different drums have to be arranged in accordance with their hazardous nature and degree of use, which will facilitate loading and unloading. All materials have to be suitably labelled, indicating their characteristics and special rules of handling. It is also of interest to store the containers in accordance with the packager's or manufacturer's instructions.

• When stacking materials, always place the liquids below the solids and maintain the containers tightly closed.

• Cleaning the surfaces immediately prior to painting, in order to prevent them from becoming dirty during the storage period.

• Establishing a stock management system in accordance with the FIFO system *(first in, first out),* which guarantees that the materials stored the longest are the first to leave.

• Using containers with a size suited to the intended use and the product characteristics and purchasing wholesale products, except in the case of materials with short shelf life or those which are not consumed in large quantities. On the whole, this makes it possible to reduce the number of containers, as well as the product lost through adhesion to the container walls. Moreover, it is preferable to use reusable containers, such as those made of polyethylene, which can be used again and, in addition, are easy to transport and to clean. However, the containers should be emptied completely to reduce the amount of cleaning agents required.

• In the special case of waste, it is recommended to provide and adapt a specific area for their storage, as indicated above, with a sufficent number of containers, so that they can be properly separated, depending on whether they are liquids or solids, hazardous or inert. Those which are hazardous must be separated depending on their composition and finally separated according to the different types of waste subject to valuation (scrap iron, plastics, cardboard, paper, etc.) in order to reuse them or reduce their volume.

2. *Control of stock*

The fundamental consequence of the control of stock is that the company does not have more materials, products and by-products in the plant than those really necessary for one reason or another. Apart from the space they occupy and the immobility caused by this, the absence of control of stock could lead to the generation of waste originating from raw materials and unnecessary products which have passed their best-before date or are spoiled, which means an additional cost to the company.

As proposals for Good Housekeeping Practices, the following may be mentioned:

• Define the frequency and responsibility for the stock.

• Avoid purchasing too many products which could pass their best-before date and become waste.

• Standardise, whenever possible, the purchased materials, and use the lowest possible number of different compounds for the same purpose. This means a reduction in the purchase and maintenance costs, simplifies the control of stock, improves tracing and using the materials, and allows the quantity and variety of waste which has to be managed to be reduced.

• Label and record all materials received, indicating the name of the product, the date of entry in storage and the best-before date (if it has one) . Check at the same time whether the material is adequately labelled.

• Purchase only the amount of material absolutely necessary for each specific production step, so that no material is left over.

• Check all materials on receipt, verifying that they fulfil all the manufacturer's specifications, and return those which do not fulfill them.

• Follow the supplier's and manufacturer's specifications regarding use, handling, storage and treatment of the materials received.

• When consuming the materials, use, as already said, a FIFO management system, with rotation of the containers situated at the back of the shelves towards the front when new material arrives. In any case, give written instructions and make the workers aware of the fact that they should first use the products which pass their best-before date earlier.

• Reduce the amount of partially full containers and promote the use of material left over from previous processes. In this respect, it is very important to adapt the container size to the amount of material necessary for each stage, as also already said above.

• In the specific case of stored waste, it is also necessary to establish the correct quantity for external management and indicate the name of the waste material, the handling and storage instructions, the name, phone and code of the authorised haulage firms and managers, etc.

3. *Material handling*

During the handling, transporting, and transfer operations, etc., both of materials and waste, a series of measures have to be adopted to avoid spillage, leaks, contamination of materials, etc., which involve losses and generate pollution. For example, contamination of a residue due to improper handling or segregation can generate an increased volume of waste, reduce the possibilities of valuation or lead to their being classified as special waste.

Among others, we can recommend the following Good Housekeeping Practices:

• The loading and unloading areas have to be well lit, marked, clean and without obstacles, especially the passage ways.

• Establish written procedures for all loading, unloading and transfer operations and pay special attention to the physical loading and unloading process: handling of pallets, drums, fork-lift trucks, pallet trucks, pumps, etc. It is highly recommended to check and inspect the equipment to be used—pumps, guns, seals, valves— before starting any transfer operation, especially when the products are liquids (for example, solvents and paints).

• It is also necessary to prepare written maintenance procedures and to perform regular checks of the condition of the premises used for the loading, unloading and transfer of products; connections, seals, valve locks, tubes, pumps, etc.

- Arrange the tanks and containers in such a manner that they cannot break and facilitate the detection of cracks and corrosion. Metallic drums, for example, have to be kept away from the ground by means of wooden pallets to avoid corrosion from the humidity of the ground.
- The containers have to be used following the manufacturer's instructions and only for its original use and it must be guaranteed that everybody receives a control and management program in good conditions.
- Reserve impermeable and clean contention areas in the proximity of the tanks and the storage areas which contain elements —retention boxes and basins— for collecting any leaked material. In these areas, the material must be separated according to their chemical and hazardous nature, and any contact with the general water collection system of the premises must be avoided.
- Make sure that the right liquid is transferred to the right container, which is why the labelling rules have to be observed, which allows the contents of the stored drums to be known at any time, as already noted above.
- Install systems which allow the amount of volume in the tanks owned by the company to be known at any time, avoid overfilling of the tanks or containers and always check the level in the container the liquid is transferred to, before starting the operation, to ensure that there is enough room available.
- In the transfer areas, install systems which give the worker sufficient time to drain the elements used in the operation carried out, especially in the area for transferring liquids. This draining has to be carried out into a vessel that allows the product to be recovered.
- In the operations for transferring liquids, proceed with special care to avoid possible splashing and spillage and use the equipment in a suitable manner (pump, funnel, etc.).
- Avoid unnecessary movement of materials through careful planning; transport the right amount to the right place.
- Have suitable absorbent materials for the products usually handled within easy reach in case of leaks. Accordingly, they should be placed near the handling areas and have to be readily available to the personnel in charge of operations.

4. *Plant operations*

Below a number of advisable steps to be followed during the application of paints and all other related activities are given aimed at avoiding the generation of pollution:

- Let the paint pots and drums drain well.
- Know the composition of the paints used at the factory and the possible hazardous substances. In this respect, it is very important to request product safety sheets and maintain them up-to-date.
- Calculate correctly the amount of paint necessary for each paint job and be sure to program changes in order to minimise cleaning and left-over material.
- Regulate the paint application parameters, in order to minimise the loss of material due to overspray. The important parameters to keep in mind are the following:

—air pressure (must be around 5-6 kg/cm^2)
—distance of the gun from the surface to be painted (must be about 15 cm)
—angle of application (perpendicular to the surface)
—rate of paint application (between 0.3 and 0.5 l/min)
—activate paint spraying at the beginning and end of each coat
—form of the spray applied (depending on each part to be painted, so that it adapts itself thereto).

- Study the design of the connections of tubes, pumps and tanks on the premises so that the portion to be drained and cleaned is as small as possible.
- Use balls or rubber pegs to put inside tubes when beginning to empty them, so that a fair amount of the paint content present can be recovered before cleaning them with solvents.
- Check whether the paint being applied corresponds to the work that has to be done.
- Do not mix products which are incompatible with one another.
- Avoid spills and splashes.
- Check regularly to ensure that taps and connections do not drip.
- If possible, use, as the adjusting solvent, the one that was used for draining and cleaning the previous container containing the same paint.
- Keep the container tightly closed.
- Know the correct functioning of the machines and equipment to be used. The better they are known, the better the equipment's performance and the less likelihood of pollution.
- Make sure the surfaces to be painted are in perfect condition and do not exhibit any irregularities which could affect the final quality of the job.

5. *Maintenance and care of premises and equipment*

The normal functioning of machines and equipment causes wear in them and affects their performance, which leads to the generation of products which do not comply with specifications, leaks, spills, etc. On the whole, this creates pollution which is not negligible.

Preventive maintenance consists in regular inspection and cleaning of equipment and premises, including lubrication, checking and replacement of parts in poor condition, which constitutes a good practice for minimising pollutants. In general terms, the amount of waste and emissions generated by leaks and products which do not comply with specifications can be reduced, thus increasing the service life of the equipment and improving the productivity of the company.

The main measures of Good Housekeeping Practices, which contribute to the correct care of the premises and minimisation of waste, include:

- Prepare for each apparatus or machine maintenance sheets or procedures along with the operating instructions. It is important that they are within easy reach of each apparatus and specify the characteristics, optimum operation and suitable maintenance. In addition, each sheet must include the frequency and cleaning method for the equipment, any small adjustments carried out, lubrication, and replacement of small parts. It is also convenient that they contain a written record of past malfunctions, parts changed, adjustments carried out, dates of checks and repairs, etc. On the other hand, they should indicate where used parts and possible waste generated —oils, metal parts, dirty cloths, etc.— have to be deposited. These sheets may be in the form of data or computerised cards.

• Also prepare sheets indicating the incidents for each production line or area where the personnel writes down the malfunctions, the dripping of valves or seals, equipment shut-downs, etc., which may affect production.

• It is fundamental to inform and train the personnel in charge of maintenance to ensure that they follow the written procedures and observe the established checking frequency. This aspect is also of special importance for the management of waste generated as a result of maintenance operations (dirty solvents, dirty sawdust, dirty cloths, etc.). In this case, it is important not to mix them or pile them up in the place reserved for this purpose.

• For certain elements and equipment (for example combustion apparatus, fork-lift trucks,), it is preferable to subcontract the preventive maintenance to a specialised outside firm.

6. *Cleaning of equipment and premises*

As already indicated above, there are different means for avoiding accidental spills and leaks, for handling the products correctly and for using suitable elements for the transfer of liquids, etc. However, despite all the preventive measures mentioned, part of the materials always unintentionally dirties the company's equipment and premises.

Once the necessity of cleaning arises, the sequence of recommended actions to follow is to isolate the spilled material to prevent it from spreading, collect it in a way that it is reusable or reduce its volume and finally clean the floor or the dirtied area. This sequence makes it possible to save cleaning agents and water, reduces the pollutional load of the discharged wastewater and, in the case that the product is not reusable, facilitates its segregation and management as waste.

For the cleaning of equipment and premises, the company is recommended to apply the following general rules:

1. Inform, train, supervise and increase awareness of the personnel in charge of cleaning.
2. Replace the manual systems by more efficient automatic ones.
3. Establish written cleaning procedures.

Specifically, Good Housekeeping Practices recommended in this section include the ones mentioned below:

• Establish and make known written procedures which describe, depending on the product spilled, the actions to be carried out, the order in which they have to be performed, and the materials to be used. Cleaning must be effected with maximum efficiency, using the minimum number of resources and minimising the number of cleaning operations, so as to avoid any unnecessary cleaning.

• The first objective is to isolate, whenever possible, the spill site and then to collect the spilled material in such a way that it can be reused. In the case of liquids (solvents, for example), it is important to construct retention tanks in the transfer and storage areas which must not be connected to the sewage system or internal drainage systems. For solids, it is sufficient to avoid contact of the solid with water or other products which cause it to spread.

• Have adequate material available for isolating the different types of products which are usually handled at the factory (paints, solvents) and may accidentally be spilled, such as trays or vessels to be placed under the drum and act as retention tanks for collecting the liquid which may overflow into them.

• Have adequate material available for cleaning the floor or area affected by a leak or spill, once the spill has been isolated and the spilled product recovered. This material must be readily accessible to all personnel and therefore has to be placed near the points where it may be needed most. Whenever possible, it is better to use mechanical instead of chemical cleaning.

• Clean process equipment (guns, hoses, tanks) regularly so as to maintain them in the proper condition and, at the same time, facilitate their cleaning.

• For the cleaning of equipment, try to use cascade or counter-current cleaning: for the first cleaning use the dirtiest solvent available, continue with a moderately dirty solvent and complete the operation with the minimum amount of clean solvent.

• In this respect, it is of great interest to recover and reuse the cleaning solvents in the same batch or in future batches of the same colour and grade or in very similar products, because in this way the production losses and the final quantity of waste to be treated are substantially lowered.

• As pointed out before, balls or rubber plugs should be used for emptying tubes, thus allowing the recovered paint to be reused.

• If chemical cleaning methods must be used (such as, for example, cleaning the floor with water and a degreasing solution), the control parameters to keep in mind are the time, temperature, concentration and turbulence necessary for an efficient operation. To reduce the amount of cleaning solution, it is necessary, in the following sequence:

—to clean with mechanical or non-chemical methods at the proper time and place, such as scrapers, brushes, aspirators, etc.;
—to use hoses or pressurised sprays, which save water and/or cleaning products (water, steam);
—to use water with surfactants or other products (such as dispersing agents and emulsifiers);
—to reuse water with cleaning agents from a previous cleaning for a first wash in order to achieve a concentration of pollutants and a smaller volume of dirty cleaning water.

7. *Development of and compliance with operating procedures*

The existence of documents or written operating procedures which report all the data, operations and instructions relating to the different processes carried out, as is the case with ISO 9002, guarantees that each task is well defined and, apart from improving the production efficiency, can reduce the generation of pollutants.

On the other hand, there is the possibility of wasting raw materials, inefficient processes, etc., which on the whole will contribute to greater generation of waste and increase the risk of accidents.

Especially in this section, all workers, each in his sector of responsibility, should be involved in the development and implementation of these working procedures.

As specific recommendations, the following may be mentioned:

• In the first place, select the normal operating procedures of the processes carried out most frequently at the plant. The operations with the greatest environmental impact, such as:

–manufacturing processes,

–maintenance operations,

–cleaning of equipment and premises,

–storage and transfer of materials,

–actions to be taken when faced with leaks and spills must be specified.

It is important that each procedure include an overall description of the processes, define each of the individual working steps and indicate the tasks each worker or person in charge has to carry out, the working procedure, the intended means, etc.

• Ensure that the procedures are complied with and avoid improvisations or omissions from the established instructions.

• In the case of leaks or spills, a general procedure should be available where the first actions to be taken are described and the persons-in-charge to be informed are named.

• Maintain a data record on the generation of pollutants for each process line and company area, as well as on the associated costs. The objective is to identify the areas which are in greatest need of improvement and then to evaluate the results of the improved practices.

8. *Waste segregation*

The proper segregation of the different types of waste generated at the factory makes it possible to minimise them and carry out management suited to each type of waste and increase the recycling and recovery potential, resulting in a saving of costs associated with the treatment. In contrast, the mixing of different types of waste —as is currently being done with many types of waste— results in wasting raw materials by reducing their possibilities of reuse, in contaminating waste, in a higher volume and, on the whole, in an increase in management costs.

This is why the different types of waste generated at the factory have to be separated in accordance with their characteristics. Specifically, the following recommendations may be given:

• Provide means and written instructions to allow the waste generated to be separated in accordance with the following feature:

—Separate the waste according to their physico-chemical characteristics: isolate the liquid waste from the solids, separate the special waste from the non-special and inert waste, separate the toxic waste according to the major component types. As for inert or ordinary waste, it is of interest to separate it according to type, to enable its external valuation (wood, scrap iron according to composition, plastic, etc.).

• This segregation assumes that specific containers are available which additionally should be placed close to each working area at the factory or offices, storages or the company's yard.

• As has already been mentioned in the chapter on storage, it is necessary to provide, adapt (pave, cover, etc.) and mark the area where the different containers are stored until they are taken away by an authorised manager. Each container must be adequately labelled with the type of waste, the code, the storage and handling conditions, the name and telephone number of the manager, etc., as already discussed above.

• Appoint people to be in charge of the proper use of the container and the storage area and make sure that they inform the authorised haulage firm to empty or replace it when it is full.

• Promote the reuse of packaging material, either at the company itself or by returning it to the supplier.

• Inform, train and give incentives to the company personnel as to the necessity of separating the waste.

5.2. *Recovery and recycling*

When the generation of pollutants cannot be further reduced at source, the next step is to try recover or reuse it again in the process or in another activity, even a secondary one.

In the case of DECAYPRINT, SA, the alternatives for recovery and recycling at source are directed towards:

—Recovering and recycling the dirty paint solvent.

—Recovering and recycling the water from the paint booth.

In the field of external recycling, the company is made the following proposal:

—Cleaning of the empty paint pots and drums.

Next, each of these proposals will be considered:

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* Cleaning of the paint off the equipment and premises.
- *Minimisation alternative:* Reduce solvent consumption and generate less dirty residual solvent.
- *Minimisation options:* Install a distilling apparatus for recovering dirty solvent.
- *Other flows affected:*
- *Raw materials affected:* Cleaning solvent.
- *Processes or products affected:* Cleaning of the paint application equipment and premises.
- *Possible savings in consumption of raw and auxiliary materials:* Reduction by 80% in cleaning solvent consumption.
- *Possible reduction of pollutants:* Reduction by 70% of the amount of residual solvent contaminated with paint.

- *Technical justification of each option:*

—*Testing of technology:* Small units which have been functioning in the field for years, very satisfactory results having been obtained in all cases.

—*Effect on the quality of the process or product:* None.
—*Space required:* Little, the equipment will take up approximately 1 m^3.
—*Implementation period:* Once a decision has been made, the apparatus is installed almost immediately at the factory since no modification of premises or services is required.
—*Requirements for use:* Nothing special, just follow the operating and maintenance instructions established by the manufacturer.

- *Economic justification of each option (in €):*

Expenses:
—*Equipment:* about 3,005 €/equip. Total cost: 9,015 €
—*Installation:*
—*Engineering:*
—*Services:*
—*Start up:*
—*Value of the equipment at the end of its useful life:* 601 €
—*Training:*
—*Raw materials:*
—*Pollutant management:*
—*Running:*
—*Maintenance:*
—*Others:*

Income:
—*Sale of existing equipment:*
—*Increase in the product selling price:*
—*Increase in production:*
—*Sale and/or valuation of by-products:*
—*Saving in raw or auxiliary material:* reduction by 80% of the consumption of cleaning solvents: 23,000 l x 80% = 18,400 l ; 18,400 l/year x 0.6 €/l = 11,040 €/year.
—*Saving in pollutant management:* reduction by 80% of the volume of dirty solvents: 6,000 l x 80% = 4,800 l; hence there are 1,200 left to be managed: (1,200 l x 0.02 €/l for transport) + (1,200 l x 0.42 €/l for external treatment) = 528 €/year; 2,674.5 €/year currently– 528 €/year with the alternative = 2,146.5 € savings/year.

Pay-back period: For the savings in terms of raw materials and waste management, the pay-back period is about $7\frac{1}{2}$ months.

DESCRIPTION OF MINIMISATION ALTERNATIVES

- *Waste flow analysed:* Water from paint booth.
- *Minimisation alternative:* Recycling of the water from paint booth.
- *Minimisation options:* Installing equipment for separating the pollutants by flotation of type of this water to be reused by the factory.

- *Other flows affected:* None.
- *Raw materials affected:* Water from the mains.
- *Affected processes or products:* Paint application in booths.
- *Possible savings in consumption of raw and auxiliary materials:* Reduction to zero of the consumption of water from the mains supply intended for refilling the booths each time they are emptied for external water treatment.
- *Possible reduction of pollutants:* Reduction by 100% of the waste water from the booth contaminated with paint and solvents.

- *Technical justification of each option:*

—*Testing of technology:* The are tried and tested units which have been installed in large factories which have paint application lines.
—*Effect on the quality of the process or product:* None.
—*Space required:* In view of the volume of water to be treated and its frequency of replacement, the unit could occupy approximately 2-3 m^2.
—*Implementation period:* The unit requires changing the pipeline from the booths to the unit, the electrical equipment, etc. In addition, a preceding tank for receiving the water and pumping system to the unit may be necessary. On the whole, this could mean an implementation period of about 3-4 months.
—*Requirements for use:* Apart from the operating and maintenance instructions established by the manufacturer, the person in charge of the factory has to have some knowledge of the physico-chemical waste water treatments.

- *Economic justification of each option (in €):*

Expenses:
—*Equipment:* about 15,025 €
—*Installation:* about 3,005 €
—*Engineering:*
—*Services:* 6,010 €
—*Start-up:*
—*Value of the equipment at the end of its useful life:* 1,202 €
—*Training:*
—*Raw materials:*
—*Pollution management:*
—*Running:* about 0.04 €/l x 17,000 l/year = 700 €/year
—*Maintenance:* about 901.5 €/year
—*Others:*

Income:
—*Sale of existing equipment:*
—*Increase in the sale price of the product:*

—*Increase in production:*
—*Sale and/or valuation of the by-products:*
—*Saving in raw or auxiliary material:* Reduction by 100% of the consumption of water from the mains supply for the booths: 17,000 l/year x 0.0013 €/l = 23 €/year
—*Saving in pollutant management:* Reduction by 100% of the water volume to be treated externally (according to Table 14 of management costs): 2,704.5 €/year

Pay-back period: About 13 years.

6. Other considerations

There are certain wastes which a third party can recover and recycle, depending on the treatments and operations the wastes are subjected to by the company.

DESCRIPTION OF MINIMISATION ALTERNATIVES

• *Waste flow analysed:* Empty paint pots contaminated with paint residues.
• *Minimisation alternative:* Recovery and valuation of the scrap iron originating from empty and clean pots.
• *Minimisation options:* Installing an apparatus for cleaning empty metal pots and drums.
• *Other flows affected:* Regeneration of cleaning solvents contaminated with paint.
• *Raw materials affected*: Cleaning solvent.
• *Processes or products affected:* Cleaning of equipment and premises.
• *Possible savings in consumption of raw and auxiliary materials:* None
• *Possible reduction of pollutants:* Valuation of waste which is currently being managed incorrectly.

• *Technical justification of each option:*

—*Testing of technology:* Cleaning equipment for empty pots contaminated with paint residues are used by many factories in the field.
—*Effect on the quality of the process or product:* None.
—*Space required:* The cleaning machine in question takes up little space, about 1 m^3.
—*Implementation period:* Once a decision has been made, the machine can be installed more or less immediately.

• *Economic justification of each option (in €):*

Expenses:
—*Equipment:* about 2,404 €
—*Installation:*
—*Engineering:*

—*Services:* 300.5 €
—*Start-up:*
—*Value of the equipment at the end of its useful life:* 480.8 €
—*Training:*
—*Raw materials:*
—*Waste management:*
—*Running:* about 0.3 €/pot
—*Maintenance:* about 601€/year
—*Others:*

Income:
—*Sale of existing equipment:*
—*Increase in the sale price of the product:*
—*Increase in production:*
—*Sale and/or valuation of by-products :*
—*Saving in raw or auxiliary material:* There will be an additional consumption of cleaning solvent, which, however, can be recycled if the distilling apparatus for solvents is also present.
—*Saving in pollutant management:* 9,015 €

Pay-back period: Approximately 11 months.

7. Table summarising the minimisation alternatives

Alternative	Minimisation option	Pay-back period
	REDUCTION AT SOURCE	
Raw mat. less pollutants	Water-based paints and high solid content	Cannot be calculated
Pretreatment of materials	Adjust paint viscosity with contaminated solvent	Immediate
Process modification	Purchase mixing apparatus	<6 months
Change in the prod. sequence	Plan sequence for paint application	Immediate
Good Practices	Use Good Housekeeping Practices	Immediate
	RECYCLING AND REUSE	
Reuse of dirty solvent	Purchase a distilling apparatus	7.5 months
Reuse of water from booths	Purchase a **********	13 years
Valuation of pots as scrap iron	Purchase a cleaning apparatus for pots	11 months

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The prevention of pollution during the company's production activity protects the environment, and at the same time, optimises resource exploitation and business management.

The first step towards adopting an eco-efficient business strategy is to know the processes, the waste flows generated and the opportunities for minimisation and saving for each flow which have not been exploited.

This book, compiled by the Regional Activity Centre for Cleaner Production (RAC/CP) within the framework of the Mediterranean Action Plan, presents clearly and simply, the methodology developed by the Centre for Cleaner Production Initiatives (CCPI) for undertaking the Minimisation Opportunities Environmental Diagnosis (MOED). The MOED is a tool which enables these opportunities to be identified in the company's different processes and the evaluation of possible technically and economically feasible alternatives of waste flow reduction and recycling at source.

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