



Module S14

Environmental Technologies

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1. Module Description

As well as to encourage economic growth, is vital for the EU to encourage a high degree of environmental protection, so it is necessary to decouple economic growth from negative impacts on the environment. Environmental technologies can be useful in contributing to technological innovation and also to increase European competitiveness, open up potential markets and, ultimately, create new highly skilled jobs. For example, the energy savings in industrial processes or the creation of 'clean' new cars, help to meet the challenge of climate change while reducing overall costs to consumers and society in general.

1.1. What are the "environmental technologies"?

Environmental technology is the technology that being applied does not produce side effects or transformations to the environmental balance or natural systems (ecosystems).

The environmental technology can be defined as "all technologies whose use is less environmentally harmful than relevant alternatives". These include technologies related to manage pollution (for example, air pollution control or waste management), related to products and services that are less polluting and less resource intensive (for example, fuel cells) and more effective management procedures resources (for example, water supply, energy-saving technologies). Other techniques from the standpoint of environmental protection are integrated into all sectors and soil remediation techniques. So defined, these technologies cover all economic activities and sectors, which offer lower costs and increase competitiveness by reducing energy consumption and resources and thus result in less emissions and waste.

1.2. Barriers to Environmental Technologies

Several obstacles hinder the development and wider use of environmental technologies, such as:

- Economic barriers, ranging from market prices do not reflect the external costs of products or services (such as health care costs due to urban air pollution) to the higher cost of investment in environmental technologies because perceived risk, the magnitude of the initial investment or the complexity of the transition from a traditional to environmental technology.
- Regulation and standards can also act as barriers to innovation when they are unclear or too detailed, while good legislation can stimulate environmental technology.

- An inadequate research, combined with a malfunction of the research system in European countries and deficiencies in training and data.
- Inadequate availability of venture capital to move from the planning stage to the production process.
- Lack of market demand by the public sector and consumers.

This module will introduce different strategies for implementing environmental management technologies; it will explain the concepts of eco-innovation and eco-efficiency as well as describing the types of environmental technologies and different methods of evaluation.

The module consists of the following four components:

- Component A: The Environmental Management in enterprises,
- Component B: Eco-innovation and Eco-efficiency,
- Component C: Type of environmental technology
- Component D: Environmental Technology Management.

2. Component A: Environmental Management in companies

Keywords: corrective and preventive strategy, environmental legislation

This component contains information about:

- *Influencing Factors of the company to implement sustainable management*
- *Strategies to approach the company to environmental management*

→ S14-A1 Environmental Management in Enterprise (ppt)

The company activity usually consists on the receipt of raw material which is processed with the help of water, energy and auxiliary materials for obtaining the product or the final products. During this process it is generated waste, wastewater discharges, emissions to air and noise production.

So, different factors influence in the company management, which add value to the company and until now more considered are:

1. Capital Assets
2. Financial Capability
3. Brand and image

As stakeholders:

- Investors
- Customers

But if we only consider these factors, we can not move towards sustainable, thus it is necessary to expand the factors taken into account, and also consider the following ones:

- Knowledge, know how
- Justice, Confidence
- Environment

This increases the number of stakeholders:

3. Staff
4. Partners
5. Society, citizenship

The company management is not an isolated element, but encompasses areas such as purchasing, sales, product, customers, society, environment, etc. Therefore more factors must be taken into account than those purely economic.

To implement a sustainable management or environmental performance in the company, two strategies can be carried out:

1. CORRECTIVE Strategy
2. PREVENTIVE Strategy

→ Exercise S14-A2 Corrective and preventive measures

The corrective strategy is characterized by the following criteria:

- No matter the quantity of resource consumption, because its cost against the product value is small.
- No matter what the company contaminated, because the effects are corrected by installing a sewage treatment or managing waste properly.

The corrective strategy involves several weaknesses:

- It is an independent activity in the company
- High resource consumption (energy, chemicals, ...)
- Increasing economic costs (sewage treatment, waste management, fees, taxes, reports, insurance, ...)
- Transfer pollution from one medium to another
- No adaptation to the new legislation

However, if the company adopts the preventive strategy, these weaknesses disappear, since the criteria to follow are:

- Reduction of resource consumption at source (water, energy, ...)
- Reduction of pollution at source (wastewater, waste, ...)
- Reduction of environmental risks

→ Exercise S14-A3 Pros and cons of strategic measures for environmental management

Should be used complementarily the corrective strategy, as there are environmental effects which are inevitable or impossible to remove completely.

The need for a preventive strategy is reinforced by the environmental law, whose short-medium term trends are:

- Integrated Environmental Authorization, Environmental License and Environmental Communication (IPPC approach)

- Establishment of Emission Limit Values taking into account the Best Available Techniques
- Public register of emissions at European level (PRTR)
- Air Quality
- Noise pollution
- Wastes
- Environmental Responsibility
- Greenhouse Gases
- Light pollution and odours

This legislative proliferation involves increasing environmental demands with the consequent economic costs. What leads companies to take solutions to prevent and control pollution through eco-innovation, thus ensuring the success and competitiveness of the company?

So, in the following components in this module, it is going to deep the environmental technologies, to which we can access through eco-innovation and eco-efficiency.

This module consists of four parts:

- Component A: The environmental management in enterprises
- Component B: Eco-innovation and eco-efficiency
- Component C: Types of environmental technology
- Component D: Environmental technology management

3. Component B: Eco-innovation and eco-efficiency

Keywords: innovation, eco-innovation, eco-efficiency, environmental technologies, best available techniques (BAT)

This component contains information about:

- What the eco-innovation and eco-efficiency are
- The political context of eco-innovation and its future trend

→ S14-B1 eco-innovation and eco-efficiency (ppt)

3.1. Eco-innovation and eco-efficiency

This component will begin by defining the innovation concept, according to the Oslo Manual (OECD, 2005):

- ✓ INNOVATION is the implementation / application of a new product (or service), a new process or a high degree of improvement, or marketing method or organization applied to new business practices, workplace or external relationships.
- ✓ It involves taking innovations developed by other institutions
- ✓ It does not require research and development for the company

We can distinguish different types of innovation, including:

1. Process Innovation
2. Product innovation
3. Marketing Innovation
4. Organizational Innovation

Any of these types of innovation involves a technological innovation that improves product performance. Innovation in business is fuelled by the following drivers:

- Company knowledge base
- Qualifications of staff employed
- Use of technology of information and communication tools
- Proximity of the company to research institutions
- The degree of innovation of the company

→ Exercise S14-B2: Future vision of the company

Once innovation is defined, it is time to identify the eco-innovation concept, according to the project Measuring Eco-innovation (2007):

Eco-innovation is the production, application or operation of a good, service, production process, organizational structure or management system that is new to the company, which results, during its life cycle, in reducing pollution, environmental hazards and other negative impacts associated with the use of resources, including energy use, compared with relevant alternatives.

In contrast to innovation, improvement from eco-innovation is addressed or focused on decreasing the negative environmental impacts on environment.

We can identify different types of eco-innovation:

1. Environmental Technologies
2. Organizational eco-innovation (EMAS, chain companies cooperation)
3. Eco-innovation of products and services (organic products, waste management, wastewater management, public transport, ...)
4. Eco-innovation in systems (organic farming)

Any of these types of eco-innovation provides benefits for the company, including:

- Economic cost savings
- Corporate image enhancement
- Improvement of relations with suppliers, customers and authorities
- Improvement of innovative capacity (in contact with innovative entities)
- Improving safety and health
- Improvement of employee satisfaction

Below is a table with drivers and barriers that we can find for eco-innovation:

DRIVERS	BARRIERS
<ul style="list-style-type: none"> • Appropriate legislation and subsidies / deductions on innovation • Reduction of economic costs • Improved corporate image • Market demand • Response to innovation competition • Achieving accreditation 	<ul style="list-style-type: none"> • Inappropriate legislation • Insufficient research • Lack of market demand • Unavailable technology • Inflexible productive processes • Uncertainty before innovation • Lack of technical staff • Small business size (reuse technology)

Table 1: Factors associated with favourable and unfavourable eco-innovation.

→ Exercise S14 - B3 Mind map trends of eco-innovation

Having defined both innovation and eco-innovation, it can be defined the eco-efficiency as:

- ✓ Measuring sustainability of a product or service
- ✓ Statistical measure of economic and environmental performance over a period of time (environmental productivity)

The difference between eco-innovation and eco-efficiency is based on eco-efficiency measures the sustainability of innovation which involves an environmental improvement, in other words, it measures the sustainability of eco-innovation.

The eco-innovation and eco-efficiency indicators are useful for:

- Assist the political decision-making
- Information for citizens
- Sustainability objective comparison between companies, clusters, regions, countries

These indicators are complex to obtain, so they are further developed by European projects (e.g., projects ECO-DRIVE and MEI).

3.2. Political Context

To encourage the promotion of innovation, the European Union (EU) has pursued **policies to support** this, including:

- Framework Programme for Competitiveness and Innovation (2007-2013, € 1bn)
- PRO INNO Europe: analysis of innovation policies in the EU
- Assistance at the Intellectual Property Rights (IPR Helpdesk)
- Europe INNOVA: innovation platform for SMEs. Three areas: clusters cooperation, knowledge services, eco-innovation.
- Enterprise Europe Network: distribution channel for innovation aspects

In addition to these European policies to support innovation, there are also policies supporting eco-innovation:

- Europe INNOVA:
 - Monitoring of eco-innovation
 - Eco-innovation Library
 - Eco-innovation Platform (Biochem, EcoLink +, INNOWATER, Remake)

- Seventh Framework Programme for Research and Development (2007-2013)
 - Environmental topics: 1,890 M € (sub line for env. technologies)
- Eco-innovation Green Book (for ending 2010)

Another action that is being developed within the EU, is the ETAP (Environmental Technologies Action Plan) which is described below:

- ✓ **Objective:** Development of ET (environmental technology) to improve business competitiveness
- ✓ **Action plan:**
 - From research to market: European programs, European technology platforms, verification ET,...
 - Improving market conditions: ET financial instruments, tax incentives, support for renewable and green industries, consumer awareness, specialized training, green public procurement,...
 - Acting globally: ET building in developing countries (UNEP, OECD)
- ✓ **European eco-innovation forums**
- ✓ **ETAP implementation reports:**
 - First report: January 2005
 - Second report: May 2007
- ✓ **National plans for implementation of ETAP**

In Spain, it is worth pointing out the PLANET platform, which aim is defining the R&D strategic agenda in the context of Environmental Technologies. Its objectives are based on:

- Integration of Spanish Technology Platforms
- Government support for plans and programs on ET
- Initiatives on ET qualifications

Its strategic lines are:

- Air quality and climate change
- Integrated water cycle
- Waste management, soils, sediments and other materials
- Sustainable consumption
- Eco-innovation and sustainability assessment of ET

3.3. The environmental technologies

ET is related to all technologies whose use is less environmentally harmful than relevant alternatives, and their objectives are:

- Reduce emissions and / or discharge of pollutants.
- Reducing consumption of raw materials, energy and water, without causing increases in other pollutants.
- Reduce waste generation.
- Increase recovery / recycling of substances generated and used in the process, and waste, as appropriate.
- Using less hazardous substances.

In Spain, to help businesses implement this ET, there is the possibility of lowering corporate tax rate of investments made by companies that avoid or reduce:

- Air pollution from industrial plants
- Pollutant load surface water, groundwater and marine
- Reduction, recovery and industrial waste treatment correct

Once we have defined what ET is, we can ask the differences between them and the BAT (Best Available Techniques). The differences are based on the BAT criteria are set with the IPPC Directive (Law 16/2002), defined by consensus among member countries for each sector and used as a reference for emission limit values.

Figure 1 shows the implementation advantages of the ET in an organization:

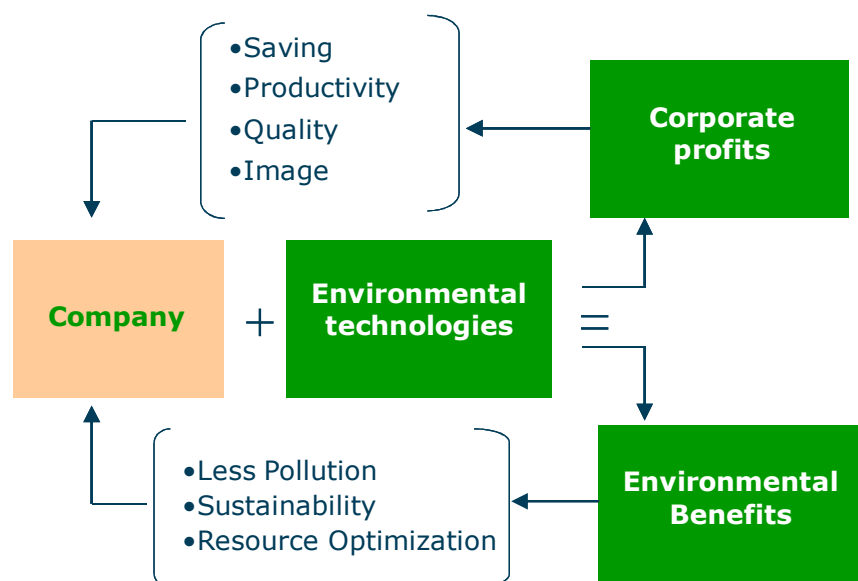


Figure 1: ET benefits

4. Component C: Environmental Technology Type

Keywords: end of pipe technologies, cleaner production technologies

This component contains information about:

- The use of environmental technologies as a form of eco-innovation
- The existing typology of environmental technologies and their benefits to business management

→ S14-C1 Type of environmental technology (ppt)

The ET, within the production process of our company, we can implement them integrated into the production process or at the end of the production line (additive or end-of-pipe), as is reflected in Figure 2.

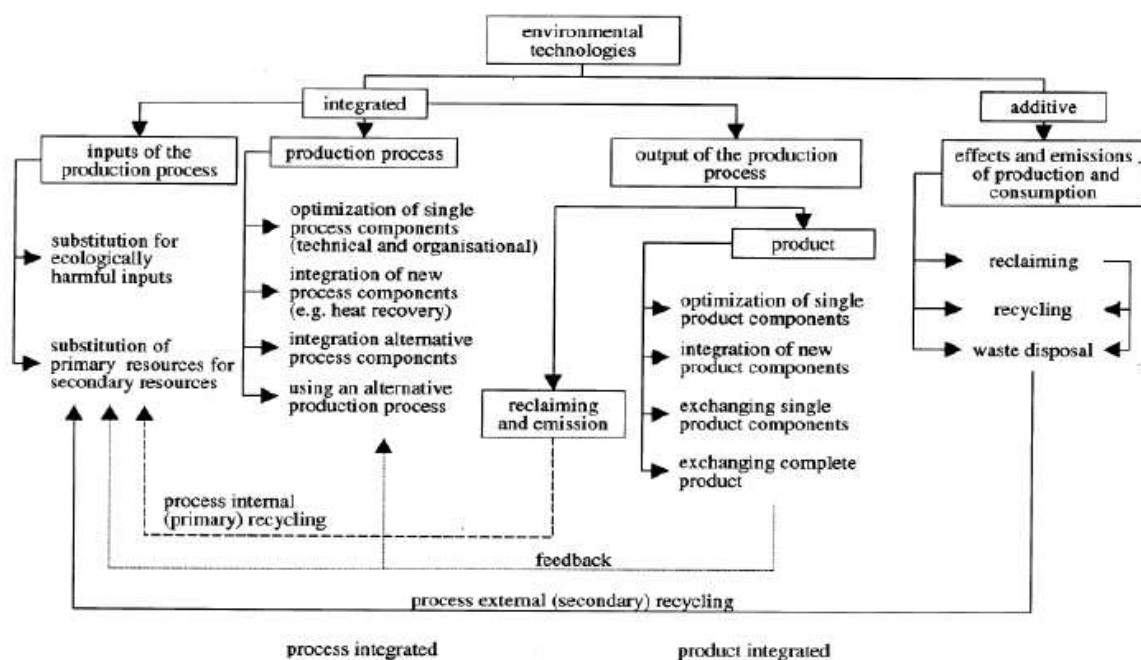


Figure 2: Types of ET (Hoymeyer y Koschel, 1995)

The end of pipe ET enables a correction of pollution, either through wastewater, air, noise or waste. However, if the company implements a cleaner production ET, pollution prevention at source is carried out in the production process, minimizing resource consumption and resulting in cleaner production, with a recycle / replacement of materials.

The cleaner production ET provides greater economic and environmental advantages compared with the end of pipe ET, so the environmental management systems (EMAS, ISO 14001) encourage the use of the integrated ET. However, although these are most

beneficial, there are the following obstacles to their use:

- Legislation that promotes the use of end of pipe ET
- Difficulty of implementation
- Difficulty of assessing the environmental improvement
- Lack of initiative from the company

Despite these obstacles and through the promotion of eco-innovation, we are seeing a turnaround in the EU, dominated by integrated ET with 66% versus 33% of end-of-pipe ET, according to the European Commission.

→ Exercise S14-C2 Flowchart

Below are shown in Table 2 some examples of ET:

ET EXAMPLES IN AIR

Modular filters and / or sleeves

Dry electrostatic

Wet electrostatic

Installing spray to minimize dust emissions

Burner low Nox emissions

Selective non-catalytic reduction of NOx emissions

Catalytic Oxidation

Treatment Unit VOC thermal oxidation and heat recovery

Muffler noise absorbent, soundproofing, etc.

ET EXAMPLES IN WATER

Pre-treatment systems

Primary treatment

Secondary Treatment

Ultra filtration

Reverse Osmosis

Water Recycling

ET EXAMPLES IN WASTE

Compactor, garbage, etc.

Waste store

Reducing packaging

Waste reduction: transportation systems, numerical control centres, conditioning of store raw materials, ...

ET EXAMPLES IN ENERGY

Design of electrical and electronic equipment

Gasification

Biomass combustion

Anaerobic digestion

Electric generation

Hot Water

LED

Table 2: Examples of Environmental Technologies

→ Exercise S14-C3 Sankey diagram

5. Component D: Management of environmental technologies

Keywords: evaluation methodologies, lifecycle analysis, multi-criteria decision making techniques

This component contains information about:

- How technology can be evaluated environmental
- Where to find information on existing environmental technology.

→ S14-D1 Management of environmental technology (ppt)

5.1. Election of ET

The choice of an ET is a very important decision because:

- It should not involve excessive costs for the company
- An inadequate ET can affect business productivity
- It influences the overall competitiveness of the company

This choice is complicated due to the wide range of technologies available, and because it requires advanced knowledge and the vast amount of data to analyze:

- Consumption
- Emissions: Air, water, waste
- Environmental hazard
- Economic costs

This is compounded by the limited availability of information for ET characterization and the need to choose an evaluation methodology with its various advantages / disadvantages. The following figure is a flow chart on an ET (cascading flushing) of the metal-mechanic sector. The amount inputs / outputs reflect the difficulty involved in the characterization of the ET.

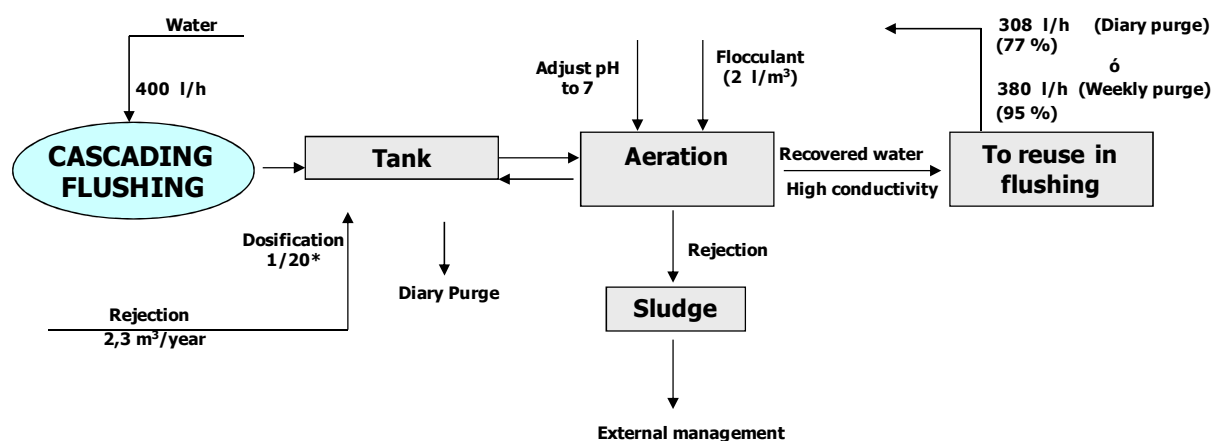


Figure 3: Flow chart of a TA

5.2. Assessment methodologies

For proper evaluation of ET depending on the activity of a particular organization, you can use different methodologies:

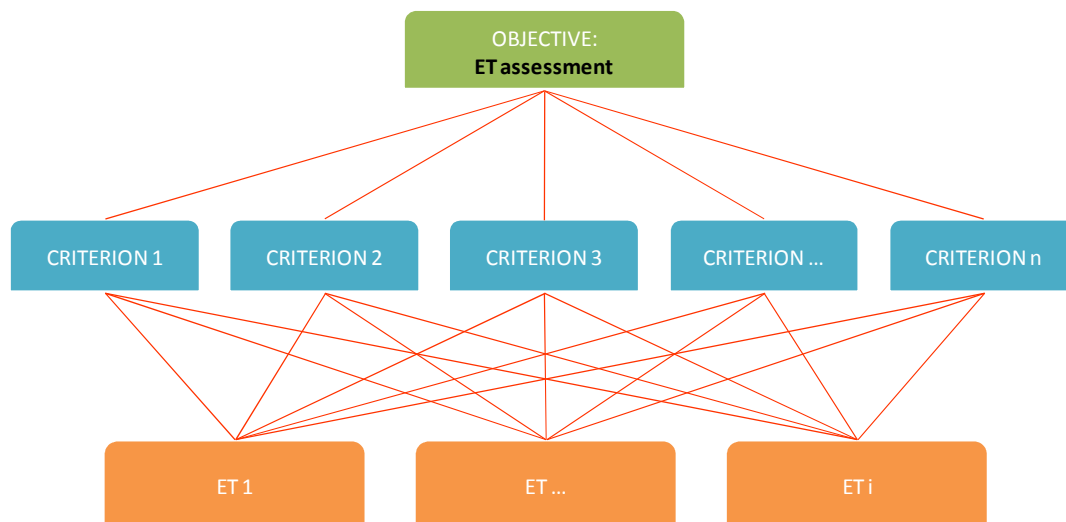
1. Life Cycle Assessment (not available yet)
2. Multi-criteria decision making techniques (MDMT):
 - a) Simple MDMT: simple hierarchy, technical merit, symbolic logic
 - b) Complex MDMT: AHP, ANP, ELECTRE, TOPSIS, PRES, opportunity cost assessment

Among the methodologies for evaluating the ET to select, it is noted the complex MDMT, in particular the AHP (Analytic Hierarchy Process), as it is useful for working with economic factors, among others. AHP is validated by numerous published examples, is an intuitive tool, it is based on pair wise comparisons and also allows you to integrate the views of a multidisciplinary team, which leads to rapid and objectives results. To use this methodology we can use the Super decisions Software.

The procedure for AHP is as follows:

1. Determine the goal.
2. Definition of assessment criteria, such as investment costs, maintenance costs, air management, effects on public health, business competitiveness, difficulty of management, energy efficiency, resource consumption...
3. It takes into account the ET available to the goal to be achieved.

After this, all the criteria are compared with ET by pairs, assigning a value to each comparison using the AHP scale.



AHP scale for comparison of pairs

1	Equally importance
3	Moderate importance of one over the other
5	Strong or demonstrated
7	Very strong or demonstrated importance
9	Extreme importance
2, 4, 6, 8	Intermediate values

Figure 4: Diagram and table of AHP scale for comparison of pairs.

→ Exercise S14-D2 is an example of ET evaluation using these multi-criteria methodologies.

In this example, two environmental technologies are compared through the AHP methodology by completing the attached tables, and using the AHP scale values.

→ Exercise S14-D3 Worksheet excel for calculating priorities with AHP

This will have to be developed:

1. Evaluation criteria matrix: the criteria are compared in pairs.
2. Priorities Matrices: both ET will be compared according to each criterion.
3. Final Matrix: are geometrically averaged individual trials and filled out the Excel sheet. This will get the highest score ET, and therefore the most appropriate and to be select.

Assessment criteria matrix				
	EC	EW	EA	WA
Economic costs	1			
Effects on water		1		
Effects on air			1	
Wastes				1
Economic costs	ET 1	ET 2		
ET 1	1			
ET 2		1		
Effects on water	ET 1	ET 2		
ET 1	1			
ET 2		1		
Effects on air	ET 1	ET 2		
ET 1	1			
ET 2		1		
Wastes	ET 1	ET 2		
ET 1	1			
ET 2		1		

Figure 5: Matrix of evaluation criteria.

5.3. Implementation and follow-up

The implementation of an ET in a company involves a series of actions or phases, continuously taken, that allow their degree of environmental improvement. After planning the deployment, it is appropriate to make an initial audit. The Minimization Opportunities Environmental Diagnosis (MOED), developed by the Environment Ministry and the Environment Department of Catalonia, is a tool that allows companies to assess their environment and focus on specific environmental aspects. After the initial audit, proposals for ET will be evaluated, implemented and monitored, which enables the achievement of the objectives set out in earlier stages.

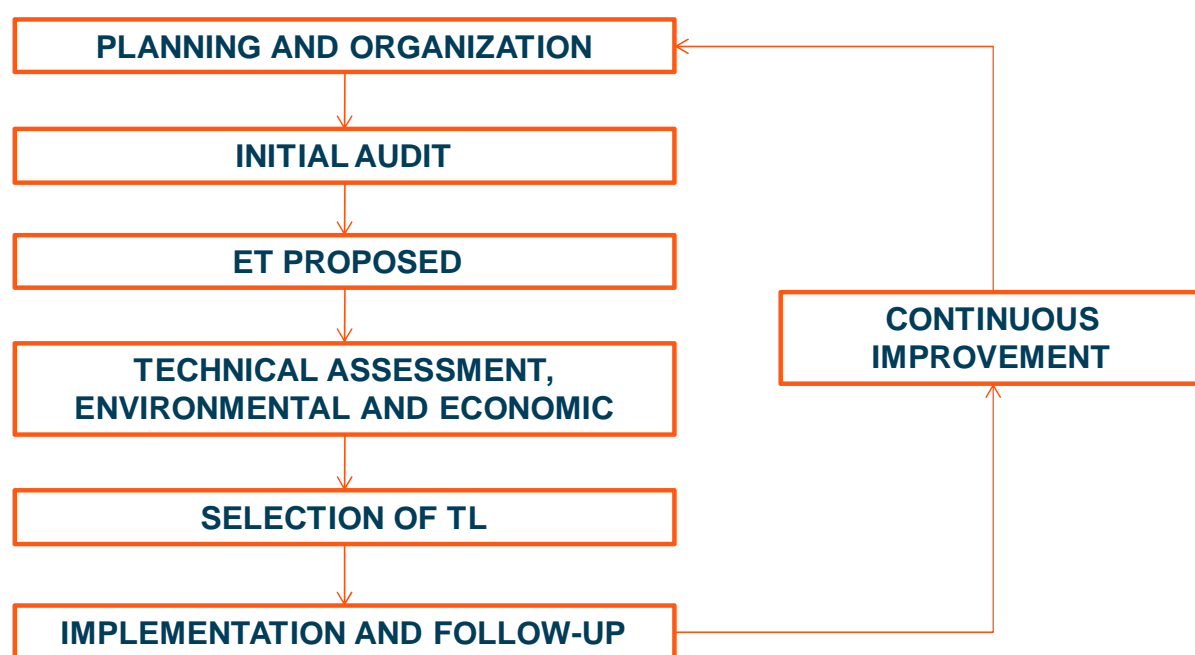


Figure 6: Phase of the ET management

5.4. Information Sources

The information sources useful for the identification of possible ET are:

1. BREF are the reference documents on best available techniques (BAT), which are not binding on IPPC companies, are developed by the IPPC Bureau and are available on <http://eippcb.jrc.es/reference/>. There are BREF published in relation to many industrial sectors: combustion, cement and lime, ammonia, acids and fertilizers, iron and steel, organic chemistry, pottery, metal rail, oil and gas refineries,...
2. The National Guidelines BAT, developed by the Ministry of Environment, is

available on www.prtr-es.es. On this website can be found 18 published guides and other guides 26 technological environmental characterization of other important industrial sectors in Spain.

3. In some autonomous regions such as Valencia, regional guides for BAT are being published, which reflect more closely the environmental characterization of their companies and their environment.
4. There are also numerous studies on ET, as published by the Clean Technologies Centre of Valencia or the Regional Activity Centre for Cleaner Production.

Other rich sources of information on ET are the technology platforms developed:

1. Spanish Technology Platforms. They deal with specific issues such as steel, construction, forestry, marine, power grids, solar, CO₂, irrigation, automotive, ...
2. European Technology Platforms. Platforms consisting of national counterparts, covering topics such as photonic components, robotics, food, animal health, textiles, drinking water, ...

The list of existing technology platforms can be found at:
<http://www.madrimasd.org/empresas/Plataformas-Tecnologicas/Europeas/default.asp>

Finally, the activity of different innovation centres to facilitate the development of new TA, such as:

1. Centre for Industrial Technological Development (CDTI), which provides support to companies to boost R & D in Spain, facilitates contact with entities of innovation, provides support for the presentation of European projects, as well as personal advice on financing of R + D + I.
2. Regional Activity Centre for Cleaner Production (CAR / PL), which has a large number of publications, studies, training activities and has developed the methodology MOED - Opportunities Environmental Diagnosis Minimization.
3. International Environmental Technology Centre (IETC-UNEP)

6. Literature

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7. Materials

S14 ENVIRONMENTAL TECHNOLOGIES

Component A: Environmental management in enterprises

S14-A1 Environmental Management in Enterprises (ppt)

S14-A2 Corrective and preventive measures

S14-A3 Pros and cons of strategic environmental management measures

Component B: Eco-innovation and eco-efficiency

S14-B1 Eco-Innovation (ppt)

S14-B2 Future vision of the company

S14-B3 Mind map on trends in eco-innovation

Component C: Types of ET

S14-C1 Types of ET (ppt)

S14-C2 Flow chart

S14-C3 Sankey diagram

Component D: Management of ET

S14-D1 Management of ET (ppt)

S14-D2 AHP (Analytic Hierarchy Process)

S14-D3 Excel sheet for calculating priorities with AHP