Anticipating the Environmental Effects of Technology

A manual for
decision-makers, planners
and other technology stakeholders

UNEP IETC
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Preface

There is growing recognition of the importance of applying technologies that support the national and sub-national development process in an environmentally sound and sustainable manner. This requirement was highlighted in Agenda 21 and is now being addressed in many international, regional and national initiatives, including the International and Regional Round Tables on Cleaner Production.

New technologies, and effective and efficient use of existing technologies, are essential to increasing the capabilities of countries, especially developing countries, to achieve sustainable development, sustain the world's economy, protect the environment, and alleviate poverty and human suffering. Achievement of these goals requires improvements in the technologies currently in use and their replacement, when appropriate, by more accessible and more environmentally sound technologies.

Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they are substitutes. Environmentally sound technologies are more than just the specific application of know-how. Such technologies are the total systems that include know-how, technical procedures, goods and services, equipment, and organisational and managerial procedures. Consequently, the assessment, transfer and assimilation of these technologies involves consideration of such requirements as human resources development and other local capacity building needs. Moreover, environmentally sound technologies should be compatible with nationally determined socioeconomic, cultural and environmental priorities.

Sometimes the environmental and human health and safety impacts of a proposed technology innovation are overlooked by those advocating the use of a new or upgraded technology. Policies that promote the development and use of environmentally sound technologies (often called "cleaner technologies" in the context of pollution prevention and control) have been adopted by many national agencies. An important aspect of implementing such policies is the ability to recognise the cleanest technology among all the options under consideration. Without an appropriate method for evaluating technology options in terms of their environmental and related impacts, the process of technology transfer remains a chancy affair.

Thus the tool of "Environmental Technology Assessment" – or EnTA for short – was born. EnTA is being developed and promoted by the United Nations Environment Programme (UNEP), in a joint initiative between the Production and Consumption Unit (PCU) of UNEP's Division of Technology, Industry and Economics and UNEP's International Environmental Technology Centre (IETC). The PCU focuses on EnTA for process technologies used by industry while IETC focuses on EnTA technologies used in urban environmental and freshwater management, whether by governments, civil society or industry.

EnTA helps ensure the right decisions are made on technology choice. These can be commercial decisions of what to import, government decisions on what processes to license, decisions on what environmental technology to adopt and apply, on regulatory decisions relating to issuing a permit, decisions by community and other groups regarding support for, or opposition to, a proposed technology innovation, and even decisions by exporters on how to market their new processes or environmental technologies. EnTA thus addresses the needs of various groups. It applies to local processes and technologies as much as imported ones, and can be used at small scale and for big industrial plants. It is just as useful for industry departments as it is to environmental organizations, since it reveals aspects of efficiency and effectiveness, infrastructure needs and supply chains.

UNEP is an advocate of EnTA for two interconnected reasons. From the production or industry perspective, an apparently easy solution to pollution is include a treatment plant as part of the technology system. But treatment plants are expensive to buy, expensive to run, and make no return on the investment. In many cases the treatment is not as effective as is desired. The cleaner production approach avoids this dilemma by using improved and environmentally sound production technologies, and more efficient operation. The result is less pollution, and a more productive enterprise - a win-win situation. But it is sometimes hard to persuade people to adopt this approach. UNEP has been promoting the cleaner production approach for over 10 years, and there is now very satisfying uptake of the approach, by both governments and the private sector. But the growing acceptance of cleaner production brings with it a growing need to identify cleaner and safer technology alternatives. It is not always appropriate to believe the enthusiastic claims of those promoting a particular technology. Technology options should be assessed in a systematic and comprehensive manner, so that the eventual choice represents the most environmentally sound alternative while at the same time meeting the other requirements for the intervention. As cleaner production becomes a household word, there is need for a tool like EnTA to facilitate the change.

On the other hand, from a consumption perspective households will always produce waste - solid waste and wastewater. Such wastes can be reduced but not totally avoided. Waste avoidance is ideal but it is not yet popular. Waste avoidance and reduction are value laden practices that require value orientation or reorientation in societies, if they are to be accepted. Much of the responsibility to ensure people and individuals are aware of the appropriate values and of the 'soft' technologies to apply (such as the appropriate management systems and procedures, and the practices that avoid waste, reduce waste or reuse or recycle waste) rests with municipal and other local government authorities. EnTA is a method that will help such government agencies, and local communities, identify and select the most appropriate technology option.

This Manual has been developed by UNEP to inform and guide planners, decision makers and other stakeholders regarding a practical tool that will help them identify the potential impacts of different technological choices, before any environmental problems occur. The tool aims to assist stakeholders to make informed choices about technologies that are compatible with sustainable development goals. In its simplest form, EnTA is about helping people make good choices – for the environment, as well as for themselves.

The Manual presents a practical and structured approach to analysing the consequences of, and the alternatives to a proposed technology intervention. The techniques used are qualitative and exploratory. While not all environmental and related issues associated with a technology will be considered in depth, the assessment should lead to recognition of the major concerns, guide selection of the best option, and indicate whether a more in-depth analysis would be appropriate.

The Manual provides practical suggestions for the use of EnTA in ways that are designed to help facilitate a dialogue between multiple stakeholders, ultimately leading to a more informed choice between selected technological alternatives. The procedures described in this Manual are not intended to discourage technological development or restrict technological choices. Rather, they are aimed at improving the environmental outcomes associated with the decisions made by planners and others making choices related to technologies.

The Manual has undergone considerable internal and peer review. In addition, the Manual and its integral workbook and worksheets have been trialed at two workshops where participants from governmental environmental and other agencies, from industry, educational institutions and non-governmental organisations, were trained in the use and application of EnTA. UNEP worked with partner organisations to ensure the success of the training activities and to ensure identification of the strengths and limitations of the Manual and ways in which the Manual might be improved. Each workshop was based around a case study – technologies for recycling used lead acid batteries and assessment of the use of cyanide processing by the mining industry.

Lead acid battery recycling is also presented as a case study in the Manual.

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Introduction

Development is often described in terms of the successive advances in technology. For example, the steam age, the industrial age, and the information technology age all refer to different historical periods. We now live in a world that is highly reliant upon technology for food, employment and economic prosperity. Although technological advancements have improved the quality of life of many people, they have also been a source of significant social and environmental disruption. Some dramatic examples of failed technological initiatives include:

- The environmental and social consequences of the Aswan Dam in Egypt;
- The legacy of the Chernobyl nuclear accident;
- The disastrous aftermath of accidental chemical releases at Bhopal; and
- The effects of acid rain on the natural and built environments in parts of Asia, Europe, and North America.

These problems resulted from the implementation of industrial processes where the possible effects upon the environment, and human health, safety and welfare, were not fully anticipated or appreciated.

Technology develops as a response to a perceived problem, need, or desire. Very often several solutions are available to address a given situation. Being able to select the most appropriate technology initially can reduce the potentially disastrous social, economic and environmental impacts that an inappropriate choice may have in the longer term. In many instances failure of a technology occurs as a consequence of events that have not been identified and planned for in advance. All too often, such adverse effects are unnecessary and avoidable. If the potential problems and risks are highlighted at the start of the development process they can often be avoided, or reduced to an acceptable level.

This Manual has been developed by the United Nations Environmental Programme (UNEP) in order to give planners, decision makers and other stakeholders a practical tool that will help them identify the potential impacts of different technological choices, before any environmental problems occur. Called Environmental Technology Assessment (EnTA), this tool aims to assist stakeholders to make informed choices about technologies that are compatible with sustainable development goals. In its simplest form, EnTA is about helping people make good choices – for the environment, as well as for themselves.

The Manual presents relevant background material, a workbook containing more detailed and comprehensive description of the steps of an EnTA, worksheets on which the workbook is based, and a case study that provides an example of an EnTA, based on the workbook and worksheets.

Goals of the EnTA Manual

The goal of this Manual is to provide technology users, decision-makers, and other stakeholders with a structured approach to analysing the consequences of, and the alternatives to, a given technology. However, obtaining detailed information regarding the technical aspects and implications of a technology is often a major constraint. The approach taken here is therefore qualitative and exploratory. Although the assessment procedures described here will not be able to address all issues associated with a technology, they should lead to recognition of the major concerns and indicate whether and where a more in-depth analysis would be appropriate.

This Manual gives practical suggestions for the use of EnTA to help facilitate a dialogue between multiple stakeholders, ultimately leading to a more informed choice between selected technological alternatives in the early stages of the development process. The Manual is intended to provide multiple stakeholders with a relatively rapid and straightforward approach to assessing the environmental implications of small, medium and large scale technological developments.

The procedures described in this Manual are not intended to discourage technological development or restrict technological choices. Rather, they are aimed at improving the environmental outcomes associated with the decisions made by planners and others making choices related to technologies.

The Manual, including the workbook, should be seen as outlining the major, critical steps in the technology assessment process. It cannot fully identify and evaluate even the full range of environmental implications of a technology. However, the issues raised while following the steps described in the workbook, and completing the worksheets, will allow a technology stakeholder to better direct their efforts, and available resources, in any later work that might be required.

Who should use this Manual?

As EnTA is a descriptive assessment of a technology, different stakeholders can use it in a variety of ways. In general this Manual is designed to help anyone who uses, or will be effected by, a technology-based decision. Potential users include:

- **Decision makers and managers in industry** – to recognise the wider environmental implications of their actions and avoid costly problems and legal difficulties.

- **Development planners and other government officials** – to ensure that the impacts of technology-based development can be identified and planned for in advance.

- **Community and other non-governmental organisations** – to help ensure that the rights and responsibilities of individuals and communities are given due recognition when technology-based developments are being considered.

- **All individuals and groups with a commitment to sustainable development** – to help ensure that the best possible environmental outcomes are contemplated, and implemented, whenever a new technology intervention is proposed.

The Manual has been designed to enable people with different skills and experience to apply the principles and procedures of EnTA to their specific needs. The workbook has been structured to facilitate the application of the EnTA process to most technological interventions, regardless of size, type or level of development of the country involved.

How to use this Manual

This Manual, including the workbook and worksheets, has been structured to answer four fundamental questions:

- Who should do an Environmental Technology Assessment?
- Why undertake an Environmental Technology Assessment?
- What are the major components of an Environmental Technology Assessment?
- How do you conduct an Environmental Technology Assessment?

It is recommended that a user first reads through the entire Manual, including reviewing the case study in Annex 2, before embarking on any practical application of EnTA. This will lead to an early understanding as to how the key elements of an EnTA fit together and will provide guidance on conducting a specific EnTA. The EnTA case study for lead-acid battery recycling, included in Annex 2 of this Manual, is intended to provide useful guidance on best practices to be adopted in conducting an assessment.

If a potential user of the EnTA procedures is well informed on matters such as environmental, economic and social impact assessments they may choose to proceed directly to the reading of the workbook and use of the worksheets.

Environmental Technology Assessment - EnTA

Technology Assessment (TA) was developed when it became clear that new technologies had many undesirable social, environmental, cultural, technical and economic side effects. In an attempt to avoid these consequences, technology users are now encouraged to use TA in order to systematically consider and weigh up the positive and negative effects of a proposed use of technology to address an identified need, or to solve a given problem.

TA was designed to help people make better choices by encouraging them to assess the effects of different technological options using a broad range of criteria, rather than focusing only on short term production goals. By rating the performance of the range of technology options against these criteria, a more complete picture can be obtained for the comparative benefits and disadvantages of the various options.

Further information on TA can be obtained from the relevant resources listed in Annex 1.

EnTA uses the same principles and approaches as TA, but focuses primarily upon a preliminary scoping and evaluation of the environmental consequences of specified technological options. In 1995 UNEP developed EnTA as a tool, in order to provide a straightforward method for understanding the implications of a technological choice, for use by a variety of different stakeholders with varying skills.

When undertaking an EnTA a broad interpretation of the term “environment” is appropriate. “Environment” is normally taken to include:

- ecosystems and their constituent parts, including people and communities;
- all natural and physical resources;
- intrinsic and amenity values; and
- social, economic, aesthetic and cultural conditions which affect the above, or which are affected by the above.

Characteristics of EnTA

Common characteristics of the EnTA process include:

- EnTA is a largely <u>qualitative</u> tool that minimises the need for detailed technical data;

- EnTA is designed to facilitate multi-stakeholder dialogue leading to consensus decision making;

- EnTA is intended to be used to <u>prevent</u> environmental problems, rather than solving them after the have become apparent;

- EnTA is <u>multidisciplinary</u> - technical and environmental processes can often be complex and therefore many different skills are required in assembling, combining, interpreting, and communicating information;

- EnTA involves simplifying both the relationships between the technology and its environment, and the consequences of those interactions; and

- EnTA examines the environmental effects of the entire technological system including the resources used and the wastes produced, over the full lifecycle of the technology.

A summary of the principal characteristics of EnTA is provided in Table 1.

The procedures for conducting an EnTA, as described in the Manual, should not be viewed as a "recipe" that must be followed on a rigorous basis. The assessment process can be modified and supplemented. Importantly, the EnTA procedures should evolve in ways that reflect local, national and regional circumstances.

Table 1. Summary of the characteristics of EnTA

EnTA is: • Technology focussed; • focussed at enterprise level rather than national policy level; • designed to ensure consideration of alternative technology interventions; • simplifying, flexible, largely qualitative and often subjective; • designed to involve, and reflect the interests of, multiple stakeholders; • a scoping tool - to be used at the "idea stage", rather than after development of a formal/full proposal when it is more appropriate to undertake an environmental impact assessment; • a proactive environmental management tool; • multidisciplinary in approach; • comprehensive and integrated – with respect to the full life cycle and broad implications of the technology system; • identifies if more sophisticated assessment tools should be used; and • voluntary – it is not considered to be a regulatory tool.

The role of opinion and judgement in EnTA

As acknowledged in Table 1, EnTA often involves a subjective assessment in which reliance is placed on expert judgement and on the values and opinions of the multiple stakeholders. The opinions and judgements of experts and other concerned parties involve a degree of subjectivity, especially where the required information and understanding is lacking. The use of opinions is a means of incorporating the values and views of stakeholders. Since EnTA is designed, in part, to facilitate a multi stakeholder dialogue and build a consensus, it is important that the views and judgments of both experts and non-experts are incorporated in the assessment.

Often check boxes are provided in the worksheets, in order to facilitate a more orderly approach to the assessment. As incorporation of diverse opinions is essential to the successful conclusion of an assessment, it may be appropriate to check more than one box. This might be done for two reasons, at least: i) to acknowledge that it is appropriate to reflect the differences in the opinions of stakeholders and hence in the conclusions reached by those undertaking the assessment; and ii) to acknowledge uncertainties that arise from a lack of information and/or understanding. It is important to acknowledge both variations in opinion and the existence of uncertainties, where they exist.

In all cases there is also an opportunity to provide descriptive responses that can elaborate and qualify the choices that have been made – and to elaborate on the differences in opinions and judgement, as well as the uncertainties. Both sets of information may well provide useful guidance to other stakeholders and to the decision makers.

The benefits of EnTA

The main objective of EnTA is to provide an evaluation of the environmental consequences of different technology options. These include the effect a technology has on the health and safety of the community, and on natural ecosystems and the sustainability of local resources. This will help allow the most appropriate choice of technology to be made at the start of the development process. Potential risks to the environment can be identified and thereby avoided, or at least reduced to acceptable levels. A list of some potential benefits to different stakeholders is presented in the Table 2.

Table 2. Potential benefits associated with EnTA

Business	Government	Public
• Avoiding pollution prevention and clean up costs • Avoiding regulatory problems and legal costs • Improving the environmental profile of the company within the community and marketplace • Reducing maintenance costs and improving overall performance • Lower absenteeism associated with worker injury	• Reduced health care cost from industrial accidents and emissions • Avoiding high clean up costs for pollutant spills • Able to plan ahead and better manage the environment • Maintaining the on going economic efficiency of local resource use	• Higher overall quality of life • Fewer work related illnesses and injury • Lower health risks from industrial pollutants • Maintaining social and cultural values

Damage to the environment is normally extremely expensive (in monetary or other terms), and in many cases is irreversible. This is of particular concern for those developing nations that place heavy reliance upon their often unique but very fragile natural resources. In almost every instance, a small investment that leads to selection of the most environmentally appropriate technology can be economically justified. In other words, EnTA can be a 'win-win' process for governments, technology users, other stakeholders and for the environment.

EnTA and other assessment tools

EnTA is not intended to replace other assessment tools already in use, including Environmental Impact Assessment (EIA), Risk Assessment (RA) and Life-cycle Assessment (LCA). EnTA has a different focus since it is totally oriented to identifying and evaluating both specific and broader environmental impacts, is predominantly qualitative and comparative, and examines the wider technological process over its entire life cycle. Table 3 presents compares EnTA with some commonly used environmental assessment and management tools.

Table 3. Comparisons between EnTA and selected other environmental tools

	Environmental Technology Assessment	Environmental Impact Assessment	Environmental Risk Assessment	Life Cycle Assessment
Purpose	Assesses implications of a technology and guides choices of technology	Identifies and predicts the environmental impacts of a project, policy or similar initiative; provides basis for decision on acceptability of the impacts	Risks to the environment and public health are estimated and compared in order to determine the environmental consequences of the initiative under consideration	Evaluates the environmental burdens associated with a product, process or activity, explicitly over the entire life cycle
Scope	Implications for human health, safety, and wellbeing natural resources and ecosystems; costs of the technology intervention and the monetary benefits	Impacts on natural resources, ecosystems human health, safety, and wellbeing	Assessment of risks to the environment and human health	Implications for human health, safety, and wellbeing natural resources and ecosystems
Initiator	Proponent of technology; investor; stakeholders who may be impacted	Applicant for regulatory approval	Proponent of project or other initiative; investor; stakeholders who may be impacted	Proponent of project or other initiative; investor; stakeholders who may be impacted
Approach	A systematic, comprehensive and qualitative comparison of the pressures on the environment and the resulting impacts	Requirements often prescribed by regulatory authority, including identification of impacts, mitigation and monitoring measures and consultation	Hazard identification, dose-response and exposure assessments, risk characterisation	Life-cycle inventory of energy and material requirements and wastes produced; impact analysis and improvement analysis
Timing	Prior to implementation of the technology	Prior to decision whether or not the initiative should proceed	At any time, as determined by the initiator	At any time, as determined by the initiator
Regulatory Status	None – often used to screen options before more detailed assessment	Often required under environmental protection legislation, especially for larger projects	None – may be used to give support to conclusions of assessments required by law	None – typically used by producers or consumers to assess the environmental merit

EnTA can in fact complement these other tools, helping to focus the initial assessment, and thereby promoting a better understanding of the effect a technology has upon the environment. EnTA provides a particularly valuable tool for determining whether a technology meets specific performance criteria. It highlights steps in the process where Cleaner Production techniques (such as Pollution Prevention (P2) and Toxic Use Reduction (TUR)) and tools such as Cost-Benefit Analysis and Social Impact Assessment may be applied with advantage.

Overview of EnTA

Technologies do not exist in isolation, but are affected by the environment within which they function. And in turn they affect their surroundings. Therefore, the approach taken in this Manual is to identify, in a systematic and transparent manner, both the external demands and pressures generated by a technology, as well as their likely environmental implications.

Each demand a technology generates has an impact upon aspects of the wider environment. Some of these impacts will be beneficial and some will not. While the procedures described in this Manual focus on the detrimental aspects of a technology intervention – i.e. the factors that determine if a technology is "unsuitable" for a particular application. But an opportunity to identify and assess any positive impacts is also provided. These may be important in the eventual decision to accept or reject the proposed technology intervention.

Within the Workbook five impact 'end-points' (or environmental outcome categories) have been defined. These are Human Health, Natural Environment, Global Environment, Social and Cultural Disruptions and Resource Consumption. The use of such end-points assists in assessing the potential impacts of a technology on the wider environment.

Steps in the EnTA process

To help ensure the success of an EnTA it is appropriate to develop an action plan for undertaking the assessment. Such preparations will help guarantee an orderly and effective progress through the five linked steps of the assessment. Completion of the five steps is followed by reporting and other appropriate follow-up activities. An outline of each of the activities is presented below and in Figure 1.

Preparation for the assessment:

Preparations for an EnTA include the assessment team establishing the assessment goals, developing an appropriate framework for meeting the goals, securing the commitment of key players, and identifying the resources that are available to the team. Consistent with the scale of the assessment, this phase might also involve establishing the tasks, responsibilities, timetable and a detailed budget.

Step 1. Describe the Technology:

This step includes describing the proposed technology by defining the technology options being considered, identifying the goals the technology is intended to satisfy, identifying the stakeholders and characterising the operation and development of the technology. Consultation with stakeholders and other key players is an important part of this step.

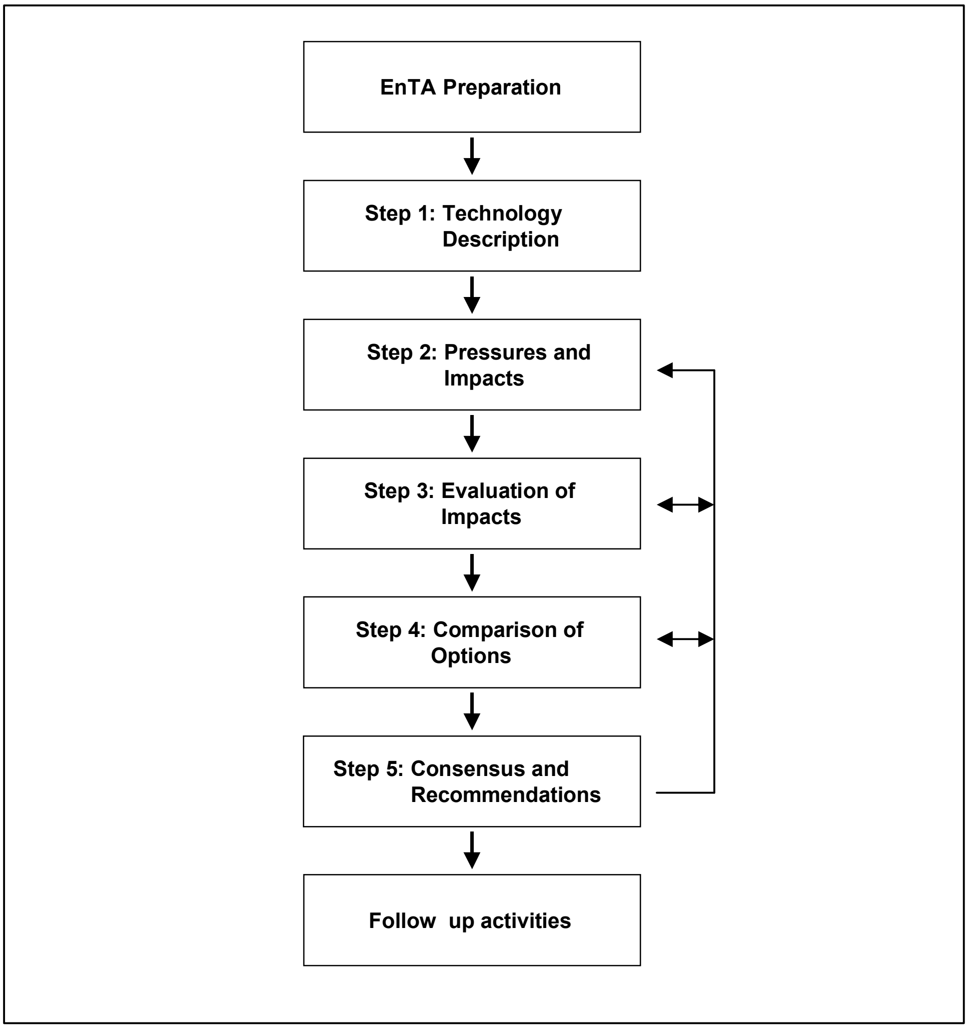

Figure 1. Overview of the EnTA Process

Step 2: Resource and other requirements, and their impacts:

This step involves identifying the raw materials, land, energy, labour, infrastructure and supporting technologies required for the technology to operate, and the wastes and hazardous products produced by the technology. The potential environmental and related impacts associated with each of these components are also characterised in this step. The inputs and outputs are considered over the lifecycle of the technology, including decommissioning.

Step 3: Preliminary Judgement:

The significance of the potential impacts identified in Step 2 are elaborated in this step, leading to an overall assessment of the environmental risks. Information gaps and uncertainties are also characterised in this step, ultimately leading to a decision whether there is sufficient information to reach a conclusion regarding the impacts and hence the appropriateness of the technology intervention.

Step 4: Comparative assessment of alternative technologies:

An important part of EnTA is consideration of alternative technologies that may also achieve the same goals as the proposed technology. Other technologies are considered in this step in order to determine if they are indeed capable of achieving the same goals, but with lower overall environmental impact.

Step 5: Decide if a consensus can be reached:

The fifth step combines all of the previously acquired information in order to determine if it is possible reach a consensus as to the suitability of the proposed technology, and any alternatives. This step also involves identification of any gaps and uncertainties in the assessment process that may prevent development of a consensus, and the resulting recommendations.

Post assessment activities:

Completion of the preceding five steps should not be considered the end of the assessment. Important actions after the completion of the previous steps include reporting the findings and recommendations to the interested parties. Other follow-up activities include monitoring of the use of the assessment findings and identifying where subsequent assessments might be strengthened on the basis of the recent experience.

EnTA is not a linear process

Although Figure 1 may be taken to suggest that the five steps of the EnTA process are sequential, this is not the case. In many instances the various steps in the assessment can be undertaken simultaneously, or in a different order to that outlined above, depending upon circumstances such as the timeframe and resources available to the assessment team. Also, EnTA should be an incremental and circular process (as Figure 1 implies), continually incorporating new information and understanding as they become available.

Alternative approaches

The Workbook can be used in two ways, depending upon the resources and time available to the assessment team. The two methods, designated the “short form” and the “long form”, are distinguished by the way in which they examine the impacts associated with alternative technological options. The differences in approach are outlined below.

Short Form

In its short form, each worksheet is completed in the order presented in the Workbook. The focus of the assessment is on one technological option. The relative impacts of alternative technologies are examined in a comparatively cursory manner, in Step 4. This provides only a preliminary comparison of the different options.

Long Form

In this approach the different components (e.g resources, waste, supporting technologies) and their associated pressures and impacts are identified for each of the alternative technological options, in the same manner and detail as was the case when the principal technology was examined. Thus the worksheets associated with Step 2 and Step 3 are completed for each of the options. This approach gives a more detailed analysis of the environmental consequences of the alternative options, but requires considerably more time and information.

Evaluating environmental consequences

The primary goal of EnTA is to identify and characterise the range of environmental consequences associated with each technological option. The approach taken in the Workbook is to encourage assessors to identify the pressures the technology will place on the environment and to subsequently evaluate the potential environmental impacts of these pressures. This is basically a three-stage process involving Identification, Characterisation and Evaluation (ICE) (see Figure 2).

- **Identify** the *pressures* the technology places on the environment.
- **Characterise** the environmental *impacts* these pressures may cause
- **Evaluate** the overall *consequences* of the impacts in light of local conditions.

For example, when investigating the impact of a manufacturing technology the assessor would need to *identify* the wastes produced, *characterise* the potential effects of the waste streams on the environment, and then *evaluate* the consequences in relation to the other environmental pressures, impacts and local conditions.

The ICE procedure proposed in this Manual is related to the more commonly used Pressure-State-Response model (more information on the PSR model is provided in the list of relevant resources provided in Annex 1). Development of policy and other responses are an integral part of the PSR model while EnTA is designed to inform the policy making process, rather than it being integral to the assessment itself. Both the ICE procedure and the PSR model have “pressure” as a common element, and hence some familiarity with the PSR model may be advantageous when undertaking an EnTA. The “state” element in the PSR model is expanded and more explicit in the ICE procedure, involving as it does both characterisation and evaluation of the impacts that may or do arise from the pressures.

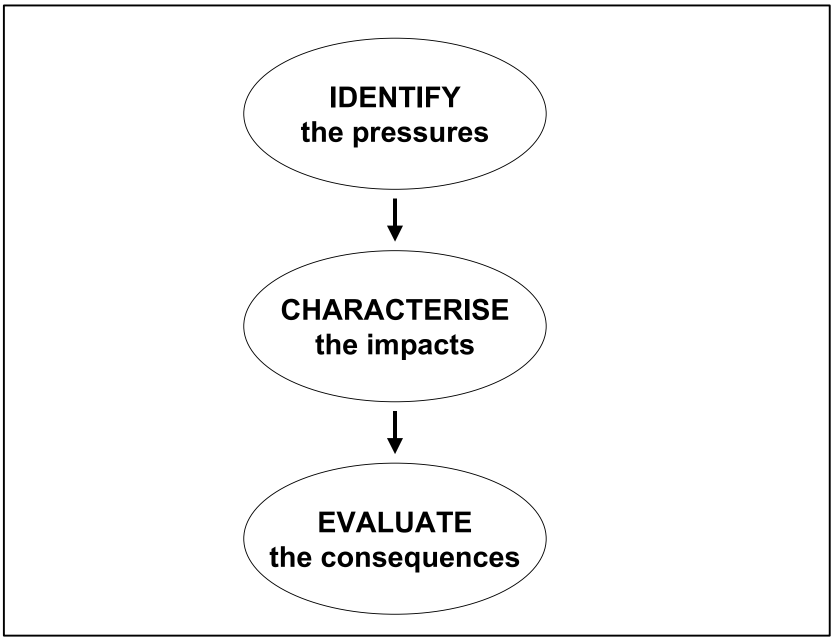

Figure 2. The ICE procedure

In this Manual five broad categories of environmental pressures are considered, along with their potential environmental impacts. The main pathways by which a technology interacts with it surroundings can normally be divided into the following categories; the material, labour and energy resources used by the technology, the wastes and hazardous products released into the environment, and the impacts of the supporting infrastructure and services.

The environmental consequences of a technology will vary with both the characteristics of the pressures (e.g. the nature and quantity of resources consumed and wastes released) and of the receiving environment (e.g. community values, hazard pathways, number of people or animals exposed, and sensitivity of the receiving environment).

Therefore, the same technology operating in different locations may have very different environmental impacts. The aim of the assessment is to determine in a systematic manner the factors, if any, that make a proposed technology unsuitable for a particular application in a particular location. The assessment attempts to locate the 'weak links' (i.e. pressure points) in the technology-environment chain. In many instances the pressure points will often be associated with the use of one or two resources, or the discharge of one or two waste products.

Pressures on the environment

The EnTA process described in this Manual addresses five major sources of environmental pressures normally associated with the different components of a technology (see Figure 3). A brief description of these components and the associated pressures is provided below.

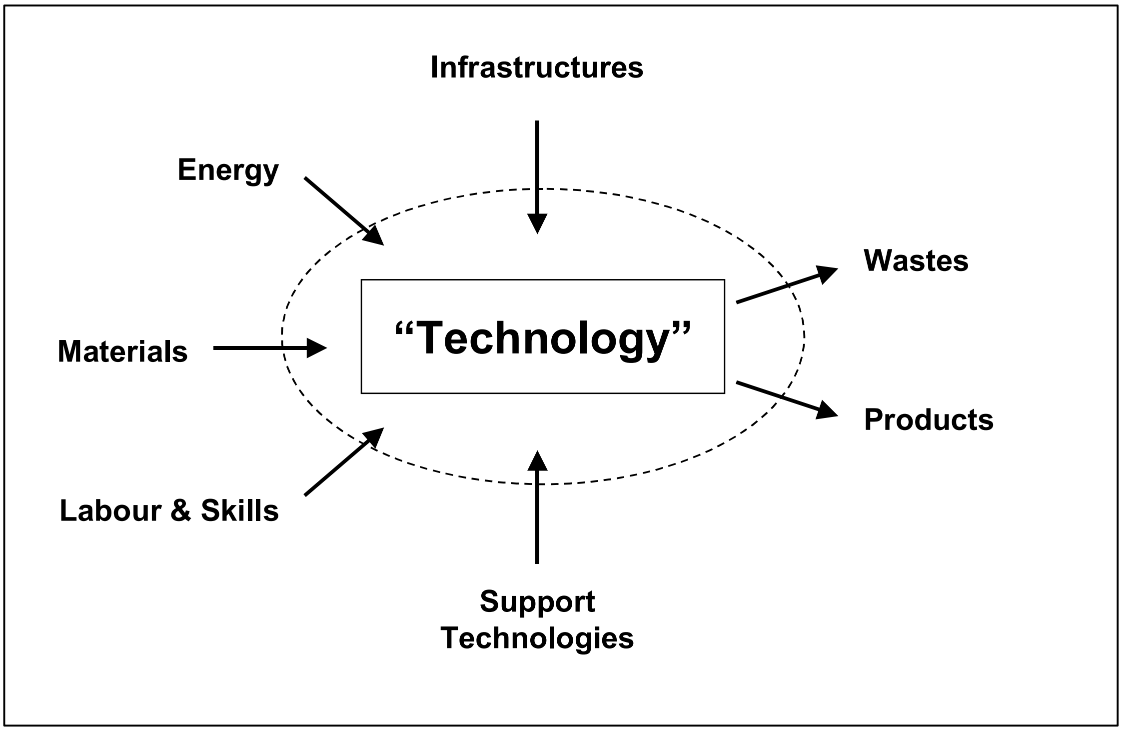

Figure 3. Components of a technological system

Resource use

This category includes all of the material, water, energy, and land resources required to establish the technology and to produce the desired outputs (e.g. services or products). Included in this category are all of the inputs to a process, as well as the support requirements (e.g. buildings, and land). Particular attention should be paid to identification of all toxic, non-renewable and scarce materials used by the technology.

Wastes and products

This category includes all of the gaseous, liquid and solid wastes produced by the technology. These are often the major source of environmental pressures. This category also includes the products produced by the technology, with attention being given to those that have the potential to cause significant pressures on environmental systems - for instance toxic substances (e.g. pesticides that may be accidentally released into the environment during storage, or transportation).

Human resources

The human resources category includes all the labour requirements needed to build, maintain, operate and eventually decommission the technology. Of special interest in this category is the number of people that may need to be recruited from outside the locality where the technology will be used. A large influx of labour can make significant demands upon the environment, resources, infrastructure and social cohesion, and on support services in a small community.

Infrastructure

The infrastructure category includes all of the supporting facilities, services and utilities needed by the technology. This might include roads, public transportation services and sewers. In this category it is important to give full consideration to the pressures arising from infrastructure changes that relate directly to introduction of the technology. In other words, the incremental and cumulative pressures that result from adding new, or expanding existing, infrastructure are considered at this stage in the EnTA.

Supporting Technologies

Technology interventions often require other supporting technologies in order to operate effectively. Examples include storage facilities and waste treatment plants. These supporting technologies place additional demands on the environment, due to such effects as resource consumption and waste emissions. The resulting pressures need to be considered if the total environmental burden of a technological change is to be fully characterised. As with the infrastructure pressures, it is especially important to incorporate the supporting technologies that will be introduced or used as a direct consequence of the proposed technology intervention.

Boundaries for the pressures associated with the technology

Each of the pressures associated with the technology will have its own life-cycle. For example, at any stage of this life-cycle the use of a resource or production of a waste may have a significant impact upon the environment.

Ideally the full life cycle of the technology intervention should be assessed – from initial concept, through design, development, procurement, operation and modification, to replacement, decommissioning or disposal. While this appears to escalate the complexity and demands of the assessment, absence of a long-term view can sometimes mean that a technology considered to be environmentally friendly in the first instance can become a significant burden on the environment some time later in its life.

It may be possible and appropriate to restrict the spatial extent of the assessment. Concerns might focus on the pressures the technology could impose on the local community, or on environmental and related systems within the national boundaries. While imposing such spatial limits may be expedient, decisions to limit the spatial scope of an assessment should be made only after careful consideration

As a further example, when considering the use of a toxic chemical in an industrial process, thought should be given to the potential for this chemical to spill or leak during either its production, transportation, storage or intended use. Similarly, the effects of a waste produced by the technology should be considered from the time it is generated at least to the time of final disposal, and often beyond that. In general, there are four main phases that should considered in an EnTA:

- **Transportation:** The transportation of resource to the technology, or the wastes from it;
- **Storage:** The storage of wastes and resources prior to use or disposal;
- **Use:** The way the resource is used in the process, including handling; and
- **Disposal:** The various environmental pathways and final disposal sites of the wastes emitted by the technology.

Types of impacts

EnTA focuses on characterising potential impacts associated with the five outcome categories, or endpoints. The outcome categories are: Human Health Impacts, Local Natural Environment Impacts, Social and Cultural Impacts, Global Impacts, and Resource Sustainability. The performance of each technology option is evaluated using these broad categories.

Each outcome category aggregates a large amount of information associated with the environmental consequences of a technology. This approach provides a useful way to combine impacts so that different technological options can be compared against common criteria. However, it must be acknowledged that specific impacts of a technology intervention may not receive appropriately detailed or balanced attention in such an approach. Moreover, there is no simple, objective way to combine impacts.

While there are various schemes that attempt to assign relative weights to individual impacts, allowing them to be subsequently aggregated in a rational way, their somewhat complex and arbitrary nature make them inappropriate for use in EnTA. One objective of the EnTA is to show if more information intensive and rigorous assessments, such as environmental risk assessment and environmental impact assessment, are necessary and justified. Such tools can provide a more rational way to aggregate impacts, resulting increased confidence in the assessment findings.

A description of each of the five categories is provided below.

Impacts involving human health and safety

This category focuses on the potential impacts of a technology on the health, safety and well being of the community and workers. Impacts may be associated with injury, discomfort or death. There are three main impact pathways that need to be considered in the assessment of human health and safety;

- Communicable Diseases - Vector borne diseases (e.g. malaria), sanitary hygiene diseases, risk associated with handing of infectious wastes;
- Injury - Risk of accidents from traffic, explosions, falls, heat stress, operation of machinery, handling of physically hazardous wastes and resources (e.g. sharps), loss of hearing; and
- Exposure to hazardous chemicals - Inhalation (e.g. air pollution), tactile contact, ingestion of contaminated food and water (e.g. pesticide residue) of hazardous chemicals, and radioactive material.

The primary focus for this category normally involves characterising the effects of chemical releases and other hazards associated with the technology. When assessing the effect of chemicals three principal questions should be asked:

- What is the toxicity or potential hazard associated with release?
- How much of this chemical is likely to be released either through normal operational practices or as a consequence of spills and other accidents?
- How many people will likely be affected by the hazard?

Impacts on the local natural environment

This category focuses on the effects a technology may have on organisms, their habitats, the life supporting capacity of natural ecosystems, and on biodiversity. Of particular concern is the loss of endangered and rare plant and animal species, and destruction of endangered and limited habitats. Three principal impact pathways should be considered when assessing impacts in this category:

- Habitat loss or alteration through land clearance (e.g. as a consequence of raw material demand or development of the site);
- Physical disruption of habitat; for example, the construction of pipelines that inhibit the migration of animals; and
- The chemical contamination of the environment through the release of wastes that have a direct toxic effect on flora and fauna (e.g. pesticides) or that alter the functionality of an ecosystem through such processes as eutrophication (e.g. the discharge of nutrients or other chemicals with high biological oxygen demand (BOD)) and acidification

Global environmental impacts

This category is concerned with the impact of the technology at a global scale, typically as a cumulative impact. These impacts may or may not be associated with a significant effect on a given local ecosystem or community. Particular emphasis is placed on the release of substances that:

- Enhance global warming (i.e. greenhouse gases such as carbon dioxide, methane and nitrous oxides); and those that
- Deplete the stratospheric ozone layer, for example chloroflurocarbons

The significance of gaseous emissions with global warming or ozone depleting potential varies with the chemical species, the amount released and the time frame over which the impacts are considered.

Impacts on scarce or non-renewable resources

This impact category relates to the effect that the technology has upon the continued existence and availability of valued and scare resources. There are two principal ways a technology can affect resource sustainability:

- By consuming a resource at a rate greater than it is replenished or greater than the rate at which it may be continually supplied over the lifetime of the technology; and

- By contaminating a resource that is either used by the technology operators or by other stakeholders, but which has no direct link to the technology (e.g. contamination of groundwater by an industrial manufacturing process)

When identifying and evaluating impacts on such resources it is necessary to consider the relative scarcity of the resource, in both local and regional or global terms, as well as the demands of the technology over its lifetime (e.g. how much will be consumed or contaminated).

In general three basic resource categories should be considered in the assessment:

- *Living Resources:* Consumption or destruction of flora and fauna resources such as crops, forests (e.g. tropical rainforests), and fisheries; also the consumption or contamination of water resources;
- *Non-living resources:* Mineral and chemical resources such as the fossil fuels used in energy generation or the materials used in production; and
- *Land resources:* The land required by the industrial site, wastes, and by supporting infrastructures and services which may reduce its potential for later use.

To evaluate the significance of resource consumption it is necessary to consider the future demands for the resource and how the technology limits the potential for this resource to be used in the future. A technology that uses recyclable materials and recycles wastes will generally have a lower impact than a process that does not.

Social impacts

This category is related to the effects of a technology on a community's values, social services and social cohesion. These impacts are in addition to those related to human health, safety and well being. There are many ways in which a technology may affect the social structure and well being of a community, but the EnTA process will normally focus on three principal concerns:

- *Cultural resources and values:* Attention is directed towards the effects a technology may have on sites or areas that have significant cultural, religious, historical, scientific or other value to the community. Possible pressures include the inappropriate use of a resource (e.g. the clearance of a site leading to disruption of culturally valued ecosystems), or the potentially detrimental effect that emissions may have on a resource (e.g. by way of acid rain). When evaluating potential consequences, consideration should also be given to visual, aesthetic and nuisance impacts. For example, an industrial plant, or power lines, might be inappropriate in a landscape well known for its historic or natural beauty, or the release of odourous compounds from an industrial process might be unacceptable to the neighbouring community.

- *Social disruption to the community:* Included here are impacts that may be associated with significant consequences for the social and economic structure of the community. Important issues that might need to be considered include the effect new workers (and their dependants) may have on the community, the possible loss of livelihood through the over use of a resource (e.g. fisheries), and the relocation of people as a result of a technological intervention.

- *Equity issues:* It is unlikely that impacts associated with a technology will be equally distributed through the community - specific sections of society may suffer disproportionately. In many instances the people most affected are those without strong institutional support. Particular attention should be paid to the potential effects of a technology development on indigenous people, the poor, children and women.

Since many of these concerns will also be related to the heath impacts and resource demands associated with the technology, it is appropriate for this impact category to be the last to be examined.

When is an impact significant?

EnTA involves a three-step approach - Identify, Characterise and Evaluate (ICE) – as noted above. The first two steps are *relatively* straightforward since generally they only require the collection of information relevant to a specific pressure induced by the technology. In contrast, often the most difficult part of an assessment is evaluating the 'significance', or 'importance', of the environmental impact produced by a particular pressure.

In the Workbook five basic questions are asked for each environmental pressure:

- Will the pressure have a significant adverse impact on the health and safety of the community and workforce?
- Will the pressure have a significant adverse impact on natural ecosystems and species?
- Will the pressure have a significant adverse impact on global warming or ozone depletion?
- Will the pressure compromise, in a significant way, the ongoing sustainable use of resources?
- Will the pressure have a significant adverse effect on society?

For wastes and other materials released by the technology into the environment useful guides for 'significance' are the emission and ambient concentration standards prepared by the relevant national regulatory agency, or developed by international bodies such as the World Health Organisation (WHO). These standards provide helpful guidance as to what pollutants are likely to be of concern, and at what concentrations they are likely to be harmful to the environment, including people. Any pollutant that is likely to exceed these concentration limits should be considered to produce a significant impact.

A more general approach is to assess the different characteristics of a potential impact. To do this it is useful to ask the following questions:

What is the effect of the impact?	What is the danger posed by this pressure (i.e. will a emission cause only a minor irritation or will it likely result in death)?
What is magnitude of the effect?	How large is the overall effect (i.e. how much land is needed, how much waste is produced)?

What is the receiving environment?	What are the characteristics of impacted environment (i.e. number of people affected, vulnerability of the ecosystem)?
What is the occurrence and duration?	How often will this happen and long will the effects last (once every year, continuous)?

Answering each of the preceding questions, even in a qualitative manner, will provide an indication of the severity of the impact and provide an initial basis for comparing impacts.

The EnTA Workbook

Introduction

This workbook describes the worksheets that facilitate completion of an EnTA. The worksheets can be reproduced as many times as required. The material in this workbook explains the purpose, the desired outputs, and the steps that are required to complete each worksheet. Reviewing Figure 1, and the relevant parts of the case study, will also help illustrate the assessment procedures. As noted previously, there are five main steps involved in completing an assessment, but in addition there are the preparations and follow-up activities. Each of these is described below.

Preparing for an EnTA

Preparation for the EnTA requires the goals of the assessment to be established, along with identification of the ways these goals will be achieved. In addition, preparations should include securing the commitment of key players in the assessment and identifying the resources (financial, human, technical etc) that are available to the assessment team. Two of these activities are elaborated below.

Establishing the goals of the assessment

It is important at the start of the EnTA process that a consensus be reached with respect to what the assessment is intended to achieve, and how this might best be done. The assessment goals should be transparent, achievable and measurable. The minimum goal of any EnTA should to ensure that:

- all stakeholders are involved in, or informed about, the assessment, as appropriate:
- all major detrimental effects associated with a technology are identified, if not fully evaluated; and
- a consensus will be reached amongst the stakeholders regarding what actions, if any, should be taken following completion of the assessment.

Identification of Resources

The resources required to complete the EnTA, and thus achieve the assessment goals, also need to be established at this stage. The resources include:

- an assessment team that has the skills and knowledge necessary to achieve the goals;
- information required in the assessment; and
- an assessment timetable, allocation of funds and access to appropriate technical resources.

Resource requirements will vary according to the scale and complexity of the technology intervention under consideration.

The methodology detailed below is designed in such a way that a person with a broad interdisciplinary background in environmental science, environmental engineering or similar areas of expertise could complete the assessment, by drawing on their own knowledge and by consulting with informed parties.

In some instances one person may not have all the knowledge required to conduct the assessment, or know how to access it. In such cases experts in the environmental and social sciences, and in engineering and economics would normally be present on the assessment team, or arrangements made for ready access to such expertise. In the more complex cases there may be considerable merit in having an individual with a regulatory background on the team. For contentious cases a representative of relevant interest groups may help facilitate successful completion of the assessment.

If the assessment is being undertaken in relation to a process technology a number of technical documents would help ensure adequacy of the information available to the assessment team. These include documents that describe the process, a process diagram, simplified materials and energy balances, the amounts and physical and chemical forms of raw materials, products and wastes, costs, conceptual basic engineering information and details of the critical points where decisions have to be made on environmental, economic and social grounds.

Step 1: Describe the proposed technology

Completion of this step requires reasonably detailed information on the following:

- Nature and function of the technology;
- Characteristics of the location;
- Principal goals the technology is intended to meet;
- Beneficiaries and other stakeholders in the technology intervention;
- Overall operation of the technology; and
- Visual representation of the inputs, outputs, processes and environmental interactions associated with the technology.

At the conclusion of this step the assessment team will have a comprehensive understanding of the life cycle of the technological system, including inputs and outputs and other resource requirements and pressures. This information is fundamental to the subsequent identification of potential environmental impacts.

At this stage of the assessment it is important to initiate consultations with the various parties (both individuals and groups) who have an interest in the technology intervention, either because of the benefits it will bring, or due to the adverse impacts they or other elements of the environment might experience.

Background

This step will help focus the assessment on the potential environmental pressures and resource demands the technology intervention will create. The level of detail provided in this step will vary depending on the assessment goals (see *Preparing for an EnTA*), and will influence the consequent scope of the assessment.

The scope of an assessment can be defined in many ways, including the time horizon, geographical scope, institutional coverage, technology options and applications, number of impact sectors and the range of policy options considered in the assessment.

In practical terms the scope of the assessment is likely to be determined by such factors as:

- expert judgement as to the importance of any subsystem to the overall findings of the assessment, in terms of such aspects as the potential impacts, the stakeholders and possible interventions to avoid or mitigate the impacts;
- limits on funds, time, personnel, information and other resources required for the assessment;
- lack of knowledge, understanding and proven methodologies related to assessment procedures; and
- political considerations such as policy implications and constraints, institutional ownership and sensitivities related to who or what might be adversely impacted.

Given considerations such as those described above, it is important at this early stage to define the scope of the assessment – i.e. the boundaries that determine what aspects of the technology intervention will be considered. These limits will determine the extent of the analysis to be undertaken in subsequent steps. For example, the boundaries placed on an assessment of lead-acid battery recycling might include the recycling network and all reprocessing and reuse steps, or it might include only the crushing, smelting and refining processes. Such process-based boundaries will often lead to the defining of spatial boundaries. The time frame used in the assessment will also influence its scope. Ideally the full life cycle of the technology intervention should be assessed – from initial concept, through design, development, procurement, operation and modification, to replacement, decommissioning or disposal. While this appears to escalate the complexity and demands of the assessment, absence of a long-term view can sometimes mean that a technology considered to be environmentally friendly in the first instance can become a significant burden on the environment some time later in its life.

The specific tasks identified in this step can be varied depending on circumstances. The fundamental requirements are a comprehensive understanding of the proposed technology intervention, clarity regarding the goals the intervention is to meet, and identification of the stakeholders who should be consulted during the course of the assessment.

Completing Step 1

a. Identify the proposed technology intervention

A descriptive name for the technology, and details of its function, should be provided.

b. Characterize the location of the technology

Brief details on site location and important features of the natural and managed surroundings, or environs, should be described.

c. Describe the technology

The technology should be described, perhaps using the check list provided. This will provide information as to whether the technology already exists at the location, or is proposed, and whether it is an indigenous technology that is to be enhanced, an imported technology (with or without adaptation to local conditions) or a new technology that is under development. It is also helpful to indicate if the technology is going to be applied to the natural resource (extractive), process/manufacturing or service sectors.

For example, in the case of a proposed battery recycling plant, the technology would be hardware based, it might be imported from abroad with little or no local adaptation and it would involve processing a waste product.

d. Describe the principal goals for the technology and identify the beneficiaries and stakeholders

The outcomes the proposed technology intervention is intended to achieve should be identified and described. A distinction is made between goals that must be achieved and those which are more discretionary. The information on goals will be referred to again in Step 4 where alternative technology interventions are assessed in terms of their ability to satisfy the same goals.

In addition, the intended beneficiaries and other stakeholders associated with each goal should be listed. This information provides a check as to whether the appropriate individuals and groups have been consulted with respect to the goals of the EnTA itself, and will be further consulted during the subsequent stages of the assessment.

e. Description of the technology

Where possible and practical, the technology intervention should be described in a logical and sequential manner. For example, description of battery recycling technologies might start at delivery of the spent batteries to the processing plant and subsequently follow the various reprocessing stages until all the resulting products and wastes have left the plant's precincts.

The functions and operations described in this step will have a significant influence on the scope of the assessment – that is, they will help define the boundaries of the assessment, as indicated above.

f. Flow diagram of the technology

A technology intervention typically has many interacting components. It is useful and informative to show these in diagrammatic form, for this will help identify the various ways in which the technology might interact with the external environment. For example, the interactions might be in the form of flows of materials and energy, including the production and discharge of wastes.

It may be desirable to show complicated and detailed sub-systems in additional diagrams.

Step 2: Resource and other requirements, and their associated environmental pressures

Completion of this step requires reasonably detailed information on the environmental pressures resulting from:

- Providing material and energy inputs and meeting other resource requirements;
- Production, storage, transportation, use and disposal of wastes and of hazardous products;
- Changes in human resources requirements;
- New or modified infrastructure requirements; and
- New or modified requirements for supporting technologies.

At the conclusion of this step the assessment team will have a comprehensive understanding of the inputs, outputs and other requirements generated by the technology intervention, the resulting pressures imposed on environmental systems and the hazards for public and occupational health.

Background

In this step the environmental pressures and human health and safety hazards that might arise from the technology intervention are identified. The resource and other requirements will typically fall into five broad categories:

- Input materials;
- Land;
- Energy;
- Human resources;
- Supporting technologies; and
- Infrastructure

All may be considered in the assessment, as appropriate.

With reference to material inputs, the aim should always be to have the lowest possible requirements. In other words, material resource productivity should be maximised wherever possible. Similarly, the energy intensity of processes should be the lowest possible. Likewise, land use per unit of production or service should be minimised.

The aim should always be to maximise the service intensity of processes, products and services. Similarly, the material and energy intensity of products and services should be the lowest possible, including enhancing the longevity and recycling potential of any products.

Non-valued outputs of the technology intervention include tangible but undesired products, the generation of which would be avoided if alternative socially acceptable, technically feasible and economically viable methods were available. Examples include waste products that are discharged to air, water or land. Such disposal will incur at least indirect costs, as well as reflecting the inefficient use of energy and materials.

Completing Step 2

a. List the raw materials, land and energy resources required by the technology, and identify the associated environmental pressures

In addition to providing a descriptive list of these requirements, each of the resource demands is characterised in terms of: i) the relative level of comparable national (or sub-national/regional or another appropriate category) demand; and ii) the pressures imposed on identified components of the environmental system.

These findings provide background to the subsequent assessment of impacts on human health and safety, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

Worksheet A provides a check list to assist in this aspect of the assessment.

b. List the wastes and hazardous products produced by the technology, and identify the associated environmental pressures

All wastes and products are recognised in terms of their potential to produce hazards or impose significant pressures on valued environmental and related systems.

The wastes and potentially hazardous products are assessed in terms of: (i) the quantities produced relative to comparable national (or sub-national/regional or another appropriate category) production; and (ii) presence of substances of concern.

These findings provide background to the subsequent assessment of the impacts on human health and safety, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

Worksheet A provides a check list to assist in this aspect of the assessment.

c. List the infrastructure required by the technology, and identify the associated environmental pressures

It is important to assess the ability of the infrastructure and services to meet the incremental demands generated by the technology intervention. Both additional infrastructure demands and the capacity of existing systems to meet these requirements in reasonable ways should be considered. The environmental pressures arising from these demands can then be identified. Worksheet A provides a check list to assist in this aspect of the assessment.

An indicative list of possible infrastructure requirements is provided in the worksheet. Those that are not applicable can be ignored, while there is space to specify additional requirements. When assessing environmental pressures the capacity of the economic, environmental, social and other relevant systems to meet these demands should be given careful consideration.

These findings are intended to provide background to the subsequent assessment of the impacts on human health and safety, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

d. List the supporting technologies required, and identify the associated environmental pressures

Typically a technology intervention will generate requirements for supporting technologies and associated services. This step involves identification of any additional requirements, over and above those previously considered in Steps 2a through 2c.

Additional technologies and associated services required to establish and maintain the technology should be listed, along with information on their availability and the associated environmental pressures. Worksheet A provides a check list to assist in this aspect of the assessment. When assessing environmental pressures the capacity of the economic, environmental, social and other relevant systems to meet these demands should be given careful consideration.

These findings are intended to provide background to the subsequent assessment of the impacts on human health and safety, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

e. List the human resources demands of the technology, and identify the associated environmental pressures

This step identifies the various skills and other abilities required to establish and maintain the technology. This step considers only those skills and other abilities directly required to implement and maintain the technology. Where additional technologies, expertise and other supporting services are also required, they will be considered in Step 2f.

Two key issues to be addressed in this step are whether the necessary expertise could be sourced locally, and whether in reality the new human resource requirements would be met by either recruiting the individuals with the requisite skills from other labour markets, or by retraining local people. Such information will assist recognition of the environmental pressures resulting from meeting the requirements for human resources. Worksheet A will also help in this respect.

These findings are intended to provide background to the subsequent assessment of the impacts on human health and safety, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

d. Identify the environmental pressures associated with any other aspects of the technology intervention

This step allows for the recognition and assessment of environmental pressures arising from aspects of the technology intervention not already identified. Worksheet A may give some help in this respect.

These findings are intended to provide background tothe subsequent assessment of the risks to human health, the local natural environment, the global environment, sustainability of resource use and impacts on society and culture (Step 3).

Step 3: Preliminary judgement

The assessments in this step build on the environmental pressures identified in a general way in Step 2, by expressing the pressures as environmental impacts and aggregating them for five environmental outcome categories, or endpoints. The economic viability of the technology intervention is also considered. Completion of this step requires additional information on the impacts likely to be imposed on valued environmental and related systems and also indicators of the economic performance of the technology.

At the conclusion of this step consideration is given to whether there is sufficient basis to reach a consensus regarding the identified environmental pressures and impacts associated with the technology, and with respect to the overall economic viability of the technology intervention.

Background

Step 2 involved assessing the pressures the technology intervention might impose on environmental and related systems. The present step considers these general findings in more detail and subsequently produces an overall assessment of the impacts for the five environmental endpoints.

A simple assessment is also undertaken in order to provide some indication of the economic viability of the technology intervention. A decision is made as to the sufficiency of information, after consideration of gaps in information and uncertainties in understanding.

Completing Step 3

Judgements as to the severity of the impacts can be aided by reference to appropriate environmental legislation, regulations, standards and guidelines (see p 21). For example, if the pressures, and consequent impacts, are likely to result in non-compliance with such requirements, the impacts should be classified as "moderate" or "large", depending on the extent of non-compliance.

Acknowledgement of diverse opinions is essential to the successful conclusion of an assessment. It may be therefore be appropriate to check more than one of the boxes provided, when recording the response for a given impact category. This might be done in order to acknowledge both variations in opinion and the existence of uncertainties (see p. 8). Uncertainty might be indicated by checking two or more adjacent boxes. A diversity of opinions could be indicated by entering in each box the number of individuals who consider that box reflects the most appropriate response.

Step 3 includes assessment of the overall impact of the technology intervention for each endpoint. In more sophisticated methodologies, such as environmental impact assessment, it is common to use weighting schemes that facilitate aggregation of the impacts for individual impact categories, resulting in an assessment of the overall impact for the given endpoint. Such an approach is inconsistent with the goal of keeping EnTA simple, and the information requirements within reasonable limits. If the EnTA findings reveal that a more comprehensive and objective assessment is required, consideration can be given to undertaking an environmental, health, social or other impact assessment, as appropriate.

Finally, the categories of impacts, and the procedures for assessing the significance of impacts are described earlier in this Manual, on p 18 and p 21, respectively.

a. Assess the impacts on human health and safety that are likely to arise from the pressures identified in Step 2

The pressures on human health and safety that were identified in Step 2 are described in terms of the impacts they are likely to cause. Any known adverse impacts on human health and safety are characterised using a three point scale, first for each impact category and subsequently overall.

b. Assess the local natural environmental impacts likely to arise from the pressures identified in Step 2

The pressures on the local natural environment that were identified in Step 2 are described in terms of the impacts they are likely to cause. Any known adverse impacts on the natural environment are characterised using a three point scale, first for each impact category and subsequently overall.

c. Assess the global environmental impacts likely to arise from the pressures identified in Step 2

The pressures on the global environment that were identified in Step 2 are described in terms of the impacts they are likely to cause. Any known adverse impacts on the global environment are characterised using a three point scale, first for each impact category and subsequently overall.

d. Assess the impacts on the sustainability of resource use likely to arise from the pressures identified in Step 2

The pressures on the sustainability of resource use that were identified in Step 2 are described in terms of the impacts they are likely to cause. Any known adverse impacts on the sustainability of resource use are characterised using a three point scale, first for each impact category and subsequently overall.

e. Assess the social impacts likely to arise from the pressures identified in Step 2

The pressures on social and cultural systems that were identified in Step 2 are described in terms of the impacts they are likely to cause. Any known adverse impacts on the social and cultural systems are characterised using a three point scale, first for each impact category and subsequently overall.

f. Assess the impacts likely to arise from pressures not identified in Step 2

Some specific pressures may not have been identified in Step 2; for example they may relate to endpoints other than the five identified in Step 2. In the present step any such pressures should be described in terms of the impacts they are likely to cause. Known adverse impacts are characterised using a three point scale, first for each impact category and subsequently overall.

g. Assess the economic viability of the proposed technology intervention

This step falls far short of a formal cost benefit or other economic assessment; it is intended to provide some indicative information that will help determine if the proposed technology intervention is economically viable. The information may also suggest that a more detailed analysis would be appropriate. The intent of this part of the assessment is to try and avoid the environmental and related damage that may occur if a technology intervention fails to meet its goals because of poor financial performance. The life cycle approach also brings attention to the consequences of providing inadequate financial resources for design and development, and for decommissioning costs. Failure to do so may lead to poor environmental performance during the technology's lifetime, and high environmental costs due to shortcomings in the decommissioning of the technology.

The aim of the first table is to identify if the cost for any category of the acquisition or sustaining costs is unusually large. A high cost is usually the result of an underlying cause. Identification of that cause may lead to the recognition of issues that bring the viability of the technology into question.

The second table gathers together some indicators of overall economic performance.

Total installed costs are the actual costs of purchasing equipment and materials, the costs of installation (e.g. labour) and also engineering costs and tax, insurance, freight and other overhead charges.

The life cycle cost (LCC) is the total installed cost plus the present value of all future expenditures (E), such as maintenance and decommissioning costs, based on an assumed discount (i.e. interest) rate (d) and a given number of years of useful life (n). Thus,

$$LCC = E / (1 + d)^n$$

The life cycle cost is sometimes called the "present value" for it includes the total installed (i.e. initial) costs and all future costs, with the latter being discounted to their present value. In theory this approach removes any effect of the timing of the occurrence of the future costs, and thus allows comparisons of technologies with different maintenance schedules and hence timing of costs. The life cycle cost also facilitates comparisons between a technology with a lower installed cost but higher maintenance costs and one which has a higher initial costs but lower maintenance costs. If the greater initial investment is to be worthwhile, the life cycle cost (i.e. the present value) of the latter technology will be lower.

The net present value (NPV) is similar to the life cycle cost, but in addition to discounting future costs (negative values), future income (positive values) is also discounted. If P equals the future costs, less the income,

$$NPV = P / (1 + d)^n$$

The payback time is one of the simplest, and therefore limited, ways of assessing the economic performance of an initiative. In its simplest form it is the cost of the project divided by the annual cash flow. If the return from the technology intervention is expected to vary from year, the expected returns for each succeeding year can be summed until the total reaches the cost of the project. Generally a payback time of three years or less is preferred. The concept of payback time has two major limitations – it ignores any benefits that occur after the payback period and it also ignores the time value of money. This latter problem can be overcome by using the net present value and the internal rate of return.

The internal rate of return is the discount rate for which NPV equals zero. This allows comparison of investment performance over comparable, fixed time periods. For example, if the internal rate of return for a technology intervention is 12% while the prevailing interest rate is 7%, investing in the technology represents a better investment. However, this conclusion ignores the complicating factor of risk – investments that offer a better payback generally carry greater risk that the assumed future income will not be paid. The internal rate of return shows how much caution will cost, or how much is to be gained if some risk is accepted.

Procedures for making these calculations and comparisons, including examples, are described in the case study.

The remainder of the second table focuses on external costs, or "externalities". These are costs that are not addressed in the calculation of present value. External costs include both monetary and non-monetary costs. An example of the former is the additional health care costs incurred by individuals living in a community impacted by air pollution from an industrial plant, where these costs are not paid for by the plant owners or operators. An example of a non-monetary cost is the value individuals place on a landscape that is not degraded due to air and other forms of pollution. Sound environmental management calls for external costs to be internalised as much as possible, thus becoming a cost of production that would be included in the calculation of the life cycle cost.

In the table some indicators of external costs have been identified. The approach taken avoids the need to express the external costs in monetary terms. That is a very challenging and controversial task. An environmentally sound and economically viable technology intervention will be one in which all the costs used as indicators will be low in relative terms, and ideally in absolute terms as well. Such a technology intervention would also give rise to few complaints from the community, regardless of the cause.

h. Describe information gaps and uncertainties

Information gaps that have impeded the assessment of impacts to the five outcome endpoints are identified. The associated uncertainties in assessing the impacts should also be described. Provision is made to identify gaps and uncertainties that are not directly related to any of the outcome categories, or are related to the assessment of the economic viability of the technology intervention.

i. Is there sufficient basis for reaching a conclusion?

Step 3 of the assessment concludes with consideration being given to whether the information gaps and uncertainties preclude the reaching of a consensus regarding the extent to which the technology will impact on the environment, and hence its acceptability.

If the information gaps and uncertainties in the assessment are such that it is not possible to reach a consensus, measures should be taken to reduce the critical gaps and uncertainties and address any other shortcomings in the approach taken to the assessment. The latter might include improved stakeholder consultation and increased participation of interested parties. Steps 2 and 3 should then be repeated.

On the other hand, if the findings, gaps and uncertainties are such that a consensus can likely be reached, Step 4 of the assessment can begin.

Step 4: Comparative assessment of alternative technologies

This step requires the assessor to consider if there are alternative ways to achieve the same goals as those to be met by the existing or proposed technology. These alternatives may be either macro (e.g. a significantly different approach) or micro (e.g. a variation of the same process) in nature. The assessor, working on behalf of all interested parties, must decide whether to consider only macro or micro alternatives, or both.

Step 4 provides the opportunity to assess if the alternative technologies are likely to have significantly higher or lower environmental impacts than the proposed technology.

At the end of this step it should be possible to identify whether there is a feasible alternative technology intervention that is associated with less adverse impacts on environmental and related systems.

Background

As noted earlier, the ultimate purpose of an EnTA is to inform the decision makers, and the stakeholders. Ideally, therefore, the assessment is not limited to examining just one proposed technology intervention. Rather, if best practice is followed, the assessment will identify and consider a range of alternative technologies, some of which might well have been overlooked if a formal EnTA had not been undertaken.

Each alternative technology should, by and large, be capable of fulfilling the articulated generic goals of the intervention. At check list to assist in making this assessment is provided as Worksheet B.

Completing Step 4

a. Identify and briefly describe alternatives to the technology being assessed

The goals to be achieved by the technology intervention were articulated in Step 1d. Desirably, one or more alternative ways to achieve these goals should be listed, and the specific nature of each alternative intervention described. Generally "No new intervention" (that is, maintain the status quo) should be considered as a possible alternative.

b. Evaluate the degree to which each alternative satisfies the goals that must be achieved by the technology intervention

With reference to each of the goals to be satisfied by the intervention, compare the extent to which the alternative technology will achieve the goal, relative to the performance of the existing or originally proposed technology.

For each goal the relevant box (or boxes if there is uncertainty or indecision) should be checked, and subsequently an assessment should be made with respect to all goals combined.

c. For each alternative technology, compare its potential impacts and economic viability, relative to the technology being assessed

This step evaluates the alternative technologies in terms of the potential environmental impacts and overall economic viability, all in relation to those identified for the existing or proposed technology. The findings of this and the previous step will, to a large extent, help decide if a more comprehensive assessment of an alternative technology is appropriate.

Each alternative technology is assessed in terms of its impacts and economic viability, relative to comparable conclusions regarding the proposed technology. This latter information was generated in Step 3. To aid the comparison, the codes describing the nature of the impacts and the overall economic viability can be transferred to the worksheets for Step 4.

Thus, for each of the five endpoints and for the economic viability, the conclusions reached in Step 3 should be transferred to the column labelled "Impact or viability of assessed technology". In each case the descriptor will be one of the following, as appropriate to the context:

- U - Impacts unknown; technology intervention uneconomic;
- B - Beneficial impacts
- N - No impacts identified;
- S - Slight impacts; slight level of concern; slight level of economic viability
- M - Moderate impacts; modest level of concern; modest level of economic viability;
- L - Large impacts; or
- H – High level of concern; economic viability is high.

As noted above, the environmental impacts and economic viability for each of the alternative technologies are expressed relative to the level of impacts and economic viability identified for the assessed technology. A five point scale is used. Guidance for determining the environmental impacts can again be obtained by consulting Worksheet A.

The level of certainty associated with each comparison should also be recorded.

It should be noted that this evaluation of each alternative technology is a very simplified analysis – described in this Manual as the “Short Form”. Where appropriate, each alternative technology should be evaluated to the same extent as the proposed technology, through the completion of Steps 1 to 3 – described in this Manual as the “Long Form”.

d. Conclusions regarding alternative technology interventions

As a result of this rapid comparative analysis it may be possible to reach a consensus regarding the performance of an alternative technology, in terms of the goals to be satisfied, the environmental outcomes and the economic performance.

Provision is made for an elaboration of the information gaps and associated uncertainties in the assessment. This information is used when arriving at a decision as to whether it is possible to reach a consensus regarding the relative performances of the alternative technology options.

If the information gaps, the uncertainties or other considerations make it impossible to reach a consensus it may be appropriate to conduct a more comprehensive assessment for one or more of the alternative options – that is, use the “Long Form” of the assessment procedures.

Step 5: Decide if a consensus decision can be reached

This is the final substantive step in the assessment. Normally completion of this step will not require any additional information. Rather, it draws on the findings of the preceding four steps.

The aim is to have reached a consensus by the conclusion of this step, specifically in terms of the environmental and related performances of the proposed technology intervention.

Background

Identification and characterisation of environmental impacts is never exact. The complexities of the environmental systems themselves, and especially the interactions related to human activities, impair our ability to specify the environmental consequences of a specific technology intervention. Due to the complex nature of environmental systems this would be the case even if all information was available. That is seldom, if ever, the case.

Recognition of the resulting uncertainties is important as it signals to decision makers the relative extent to which they can rely on the guidance provided, and hence make unequivocal and irreversible decisions. Significant uncertainty calls for a more adaptive approach to management, where flexibility is retained and options are kept open until the reduced levels of uncertainty suggest it is appropriate to do otherwise. Thus, an adaptive management approach invokes strategies for reducing uncertainties, to the extent that such efforts are reasonable.

Completing Step 5

a. Can a consensus be reached with respect to the performance of the assessed technology?

The questions to be answered in this step are designed to identify whether all steps have been completed, at least to the extent that some necessary conclusions can be reached. If there are shortcomings, suggestions are given as to which steps need to be repeated in order to move towards a conclusion.

b. Characterise the significant information gaps and uncertainties that remain

The major gaps and uncertainties identified earlier are described. As noted above, this information should be made available to the decision makers and other stakeholders, in order to show the extent to which they can rely on the guidance provided by the assessment.

c. Summarise the suitability of the technology and the level of certainty in the assessment

This step provides the opportunity to describe the environmental impacts of concern and the types of changes in the technology intervention that might result in a reduction of these impacts and hence improved acceptability of the technology.

Once again it is appropriate to describe the level of certainty in this aspect of the assessment, with the findings being made available to interested parties, along with any recommendations.

It has been noted previously that circumstances might suggest that an EnTA should be followed by a more detailed, rigorous and comprehensive assessment of the environmental performance of the proposed technology intervention. Factors influencing such a decision may well include existence of large information gaps, high levels of uncertainty, inability to reach a consensus due to the continuing polarization of views amongst stakeholders, and the serious nature of the environmental impacts that have been identified. Any one of these circumstances would indicate the need for a more comprehensive study, such as an environmental impact assessment, an environmental or health risk assessment, a comprehensive economic analysis or a social impact assessment.

The nature of the environmental impacts, the measures that may or may not be available to avoid or mitigate these impacts and the gaps and uncertainties should all be considered when making a recommendation as to whether a more comprehensive environmental assessment should be undertaken.

The acceptability of the technology being assessed should be indicated and the viability of any alternative technology interventions should be described.

Finally, the consensus recommendations regarding the assessed technology, and the identified alternatives, should be provided.

Completing the EnTA

Once the Workbook and Worksheets are completed, there are several additional steps in the EnTA process that should be considered.

Document and present the assessment methods and findings

Careful attention should be given as to how, and to whom, the results of the assessment should be communicated. For example, Step 1 identified the principal beneficiaries of the proposed technology intervention and the stakeholders who would carry the burden if the environmental values were not protected. Consultation with interested parties was also used to help identify the goals of the assessment. All these stakeholders will likely have a legitimate interest in receiving the results of the assessment. This is in addition those who will use the assessment findings to guide their decisions regarding implementation of the technology intervention.

Different circumstances may call for substantively different forms of reporting the results of the assessment, just as the breadth and depth of the assessment itself is dependent on various circumstances. In light of this, no attempt will be made to be prescriptive as to the form, style and content of formal and informal communications arising from the assessment.

However, it will normally be important for any communications to reflect:

- The interests, backgrounds and purposes of the intended recipients;
- The information and methods used in the assessment, and the resulting certainty of the findings;
- The goals of the technology intervention (step 1);
- The options for meeting the goals (Steps 1 and 4);
- The most significant environmental pressures associated with the proposed technology (Step 2);
- The major environment impacts and the economic viability (Step 3)
- The ability of alternative technology interventions to achieve the goals, and the relative environmental impacts and economic performances of these alternative options (Step 4)
- Recommendations regarding further assessments and implementation of the proposed technology intervention (Step 5)

Follow-up to assessment

As previously noted, an EnTA is not a one-off action. As new information and understanding comes to light, as the technology cycle evolves, and as values and goals change, there may well be a need to re-evaluate the assessment findings.

Follow-up activities should include, but not be limited to the following:

- Responding to the decisions, needs and actions of the key players and stakeholders;
- Revising the existing assessment and preparing new intervention strategies and recommendations;
- Undertaking, as appropriate, more comprehensive assessments of the proposed and/or alternative technologies;
- Providing additional information and guidance to key players and stakeholders;
- Monitoring and assessing relevant technology transfers, developments, implementations and uses;
- Monitoring and assessing impacts and regulatory, policy and other developments;
- Adapting the technology intervention strategy to reflect new requirements, information and understanding; and
- Revising the environmental technology assessment procedures in light of new information, experience and understanding.