Environmental Protection Act 1990 Best Practical Environmental Option and Other Assessment Methods: Case Study Comparisons

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Statement of use
This report summarises the findings of research carried out to compare appropriate methods for assessing the effects of human activities in the environment. The research also looks at how they are used in practice in order to identify and recommend techniques, models and data which could be applied in the further development of the BPEO assessment methodology developed by the Agency. The information within this document is for use by Agency staff and others involved in the development of the methodology.

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EXECUTIVE SUMMARY

Section 7(2) of the Environmental Protection Act 1990 (EPA 90) outlines the objectives that must be met by the Environment Agency (the Agency) when setting conditions in authorisations for Integrated Pollution Control (IPC). Section 7(7) further requires that where a process is one designated for central control and likely to involve the release of substances into more than one environmental compartment then a further objective must be complied with. This objective is to ensure that BATNEEC will be used to minimise pollution which may be caused to the environment taken as a whole by releases, having regard to the best practicable environmental option (BPEO) (hereafter referred to as IPC BPEO to differentiate it from other forms) as respects the substances which may be released.

To ensure compliance with Section 7(7) Her Majesty's Inspectorate of Pollution (HMIP), subsequently the Agency, has developed a Methodology for the identification of the IPC BPEO. Although HMIP and the Agency have consulted widely during the drafting of this Methodology, concerns have been voiced by industry and other interested parties about its format and applicability. The Agency has therefore commissioned research, including this study, to investigate ways in which its IPC BPEO Methodology may be further refined to increase its usefulness to process operator and inspector alike.

The specific requirements of this study were twofold. Firstly to review a number of other environmental assessment methodologies with a view to identifying any elements of them that may be used to augment and complement the IPC BPEO Methodology. Secondly to review a number of case studies that have recently been undertaken using the IPC BPEO Methodology to identify specific areas where the Agency's guidance may be improved.

One of the major issues emerging from this work is the significant differences between IPC BPEO and the more wide ranging meaning of BPEO advocated by the Royal Commission on Environmental Pollution. The lack of appreciation of this fundamental difference is one of the main reasons for criticism of the IPC BPEO Methodology.

A number of environmental assessment methodologies were reviewed. These included environmental impact assessment (EIA), environmental management systems (EMS), life cycle assessment (LCA), the Royal Commission on Environmental Pollution's (RCEP) BPEO methodology, eco-controlling and environmental risk assessment (ERA). This review indicated that elements of each methodology may inform the Agency on the refinement of its IPC BPEO Methodology but that there is no one environmental assessment methodology that could provide the answers to all of the perceived problems with the IPC BPEO Methodology, for example relating to how effects should be assessed. In fact, the other assessment methodologies may well find it beneficial to utilise elements of the Agency's IPC BPEO Methodology to address their own deficiencies, particularly in the area of assessing environmental damage or harm.

The use of the case studies to illustrate areas potentially requiring improvement has been constrained to a certain degree, largely because they were not based on situations that will arise in practice. Although the case studies covered real processes, these were ones where no changes to the actual process or control techniques were planned. In addition, the case studies concentrated on the generation of control options rather than process options, in effect

precluding a consideration of the more fundamental changes to the effects associated with a process that may have been achieved. Despite these limitations the case studies did provide some useful information on potential modifications to the guidance. For example, relating to improving the differentiation between the various approaches to BPEO assessment; broadening the available guidance on how to assess releases; addressing deficiencies in data availability; developing new ways of presenting the guidance; and the generation and screening of options.

A number of recommendations are made as to how the IPC BPEO Methodology may be further developed. These recommendations are outlined in Sections 2 (other environmental assessment methodologies) and 3 (relating to the review of the case studies) of the report, respectively. In addition, Section 1 provides an introduction to the study and Section 4 outlines its main conclusions and recommendations. The other environmental assessment methodologies are individually summarised in Appendix A to the report.

KEY WORDS

Best Practicable Environmental Option, BPEO, Integrated Pollution Control, IPC, Environmental Assessment.

1. INTRODUCTION

The Environmental Protection Act 1990 (EPA 90) requires prescribed processes in England and Wales to be authorised under Integrated Pollution Control (IPC) by the Environment Agency (the Agency).

Section 7(2) of the EPA 90 outlines the objectives that must be met by the Agency when setting conditions in authorisations for Integrated Pollution Control (IPC). Section 7(7) further requires that where a process is one designated for central control and likely to involve the release of substances into more than one environmental compartment then a further objective must be complied with. This objective is to ensure that BATNEEC will be used to minimise pollution which may be caused to the environment taken as a whole by releases having regard to the best practicable environmental option (BPEO) (hereafter referred to as IPC BPEO to differentiate it from other forms) as respects the substances which may be released.

The restriction to "result of releases" is very important, as will be seen subsequently, nevertheless even in this restricted sense, determining IPC BPEO is a non-trivial task and the Agency (in its earlier guise as Her Majesty's Inspectorate of Pollution) consulted widely on the approach that could be taken to achieve this objective. HMIP outlined its initial suggestions for an IPC BPEO Methodology in 1994 in what came to be known as the 'Orange' Book (HMIP 1994). As a result of comments on the 'Orange' Book, HMIP further refined its Methodology. The revised Methodology was in turn published as a draft Technical Guidance Note (E1) - Environmental, Economic and BPEO Assessment Principles for Integrated Pollution Control (the 'Blue' Books) (HMIP 1995). It is the 'Blue' Books that have served as the basis for this study.

The Agency now plans to further revise its IPC BPEO Methodology, in light of comments received on the 'Blue' Books and as a result of a number of research studies, including this one, that it has commissioned. This revision process is taking place within the statutory framework of the EPA 90 and in this sense does not, and cannot, address some of the more fundamental concerns expressed during the consultation process, for example relating to the types of environmental effect that may be considered during an IPC BPEO assessment. Such fundamental changes could only be initiated via changes to the EPA 90 and therefore are an issue for the Government rather than the Agency.

This study was initiated to investigate some of the key issues associated with the initial comments on the 'Orange' Book as well as to consider ways in which the IPC BPEO Methodology could be extended or improved by experience from other environmental impact assessment methodologies.

1.1 Historical development of BPEO

The term BPEO was first introduced in 1976 by the Royal Commission on Environmental Pollution (RCEP) (RCEP 1976). It was subsequently expanded in their twelfth report published in 1988 (RCEP 1988). The 12th report provides recommendations on the approach which might be followed in conducting an analysis to decide which option constitutes the BPEO for the intention concerned.

HMIP drew heavily on the RCEP's ideas in developing its own IPC BPEO Methodology. However, in doing so it had to work within the relatively narrow statutory confines of the EPA 90. Moreover, the scope of impacts considered by the RCEP is wider than that in IPC BPEO in that it does not restrict itself to impacts as a *"result of releases"*. Also the intention implied by the RCEP appears to be wider than that of operation of a prescribed process.

So it is apparent that the same term BPEO has at least two different meanings according to where the concept is used. To avoid confusion between them in this report the term IPC BPEO has been used for the more specific and restricted usage defined in the EPA 90. The term RCEP BPEO will imply the concept recommended by the RCEP, other BPEO approaches will be similarly designated.

In addition to the work of the RCEP, a number of other organizations have explored the possible utilisation of the concept of BPEO, for example, the Department of the Environment applied it to the disposal of radioactive wastes (HMSO 1986). Whilst both the Institute of Waste Management (IWM 1987) and the UK Environmental Law Association (UKELA 1987) published papers on the concept. A review of these literature sources suggests that, despite their ground breaking role at the time, there is a little they can add to the Agency's current IPC BPEO Methodology.

Shell has also applied a BPEO methodology during the debate over the disposal of the Brent Spar platform (Shell 1994). Consideration of Shell's approach suggests that it was developed to address a very specific problem and it has little to offer the Agency in terms of the refinement of its own methodology. Despite its limited technical input to this study, it should be noted that Shell's use of BPEO has done much to raise the profile of the concept and this may cause the Agency problems in the future. Shell undertook its BPEO assessment within a much broader statutory framework than that which the Agency works in. Shell therefore had considerably more flexibility than the Agency in selecting the approach it used and the effects to be assessed. Given the high profile of the Shell work compared to that of the Agency's IPC BPEO Methodology, it is possible that the public may perceive the two approaches as being one and the same. Similar problems may arise because decision making in relation to the Brent Spar was based on a consideration of 'value judgements' rather than the results of Shell's BPEO work. The Agency may face similar problems in high profile cases, particularly those involving planning permission.

The Chemical Industries Association (CIA) had a number of concerns about the initial proposals for an IPC BPEO Methodology. To illustrate these concerns and to suggest potential ways in which they could be addressed, the CIA drafted its own BPEO methodology. Subsequent discussions and the publication of the summary guidance on the use of the IPC

BPEO Methodology (Environment Agency 1996a) have allayed to a considerable extent the CIA's concerns, to the extent that it has decided to no longer pursue the development of its methodology.

Finally, one other BPEO methodology has been developed. This approach was produced for HMIP and relates solely to the disposal of sewage sludge (WRc 1990). One example of the utilisation of this approach was considered during this study.

1.2 Approach adopted for this study

The main areas of comment resulting from consultation on the Agency's draft IPC BPEO Methodology that contributed to the definition of the scope of this study were:

1. the environmental impacts considered;
2. the procedure proposed for comparing releases to different media;
3. the relationship with other regulatory measures, particularly those associated with planning and accidents;
4. the identification of "options" that were legitimate for consideration under IPC BPEO.

The objectives of the study were therefore:

- to review alternative environmental assessment methodologies;
- to consider specific case studies which provide examples of how the IPC BPEO Methodology is applied in practice;
- using the results from the above to formulate recommendations as to how IPC BPEO might be enhanced or improved.

In order to meet these objectives The study was divided into five tasks, which are summarised below:

- Task 1 - review different approaches to BPEO assessment.
- Task 2 - identify other environmental assessment methods to be studied in detail.
- Task 3 - compare concepts and terminology of the identified methods.
- Task 4 - analyse case study examples.
- Task 5 - formulate recommendations.

The main assessment methodologies identified as being of relevance to the study (environmental management systems, life cycle assessment, environmental impact assessment, risk assessment, eco-controlling and the RCEP's BPEO methodology) have been summarised in Appendix A. A synoptic comparison of these methodologies is presented in Section 2,

together with a discussion of the aspects of these other assessment methodologies that may be used to further develop the IPC BPEO Methodology. Section 3 summarises the results of the case study comparison. The key conclusions and recommendations arising out of this study are presented in Section 4.

The Agency has commissioned two other studies to look at ways in which the IPC BPEO Methodology might be improved. These cover the derivation and use of environmental assessment levels (EALs) and the feasibility of cost benefit analysis for IPC, respectively. This report does not therefore address these topics.

The Environment Agency has also taken part in the Environmental Analysis Co-operative Working Group on environmental analysis, dispersion and fate in the environment and ambient environmental quality. As a direct consequence of this work, the Co-operative has published Released Substances and their Dispersion in the Environment (RSDE) (HMSO 1996). The results of this guidance will be of considerable use in the further development and use of IPC BPEO.

Finally, the recommendations and conclusions of this report should be viewed in the context of the pending introduction in the UK of the provisions of EU Directives relating to Integrated Pollution Prevention and Control (IPPC) and the Control of Major Accident Hazards (COMAH), respectively. Implementation of these Directives in the UK is likely to have major implications for the Environment Agency, in particular for the IPC regime. Although this report has attempted to a certain extent to anticipate the implications of these Directives for IPC BPEO, it will only be possible to reach definitive conclusions on their true impact on this assessment Methodology when the implementing regulations are established and more extensive legal advice is available.

2. ANALYSIS OF OTHER ENVIRONMENTAL ASSESSMENT METHODOLOGIES

The purpose of this section is to provide an analysis of other methodologies used for the assessment of environmental impact, adopting a common framework to enable comparisons to be more readily made.

The objective in doing this review is to provide information on approaches adopted in these methodologies which could augment and complement those currently used for IPC BPEO assessment. Many of the approaches/techniques utilised in the other methodologies are not designed as comparative tools, as most simply seek to establish the environmental impact of a particular product, process or activity. Such approaches/techniques, however, could in theory be used in a comparative mode, and have therefore been included in the review.

For the purposes of this review, it is worth identifying and clarifying the scope and definitions of terms. The scope of the report has been restricted to that of industrial processes and products and the terminology used is that outlined in the Environmental Analysis Co-operative's report on Released Substances and their Dispersion in the Environment which provides guidance on 'environmental analysis' and 'environmental assessment'. Environmental analysis is the estimation of the quantity of substances released to the environment and their subsequent dispersion, while environmental assessment is the judgement of whether these releases are "acceptable".

2.1 Methodologies examined

The methodologies described have a wide variety of purposes and apply variously to processes, activities and products. These differences are essential factors in understanding the approaches taken. However, despite these differences the methodologies share a common purpose of trying to characterise in some way the environmental consequences of their specific subjects.

Summaries of each of the six assessment methodologies considered in the study are included in Appendix A to this report. These methodologies are:

1. Life cycle assessment (LCA).
2. Environmental management systems (EMS).
3. Environmental impact assessment (EIA).
4. The Royal Commission on Environmental Pollution's (RCEP) BPEO methodology.
5. Environmental risk assessment (ERA).
6. Eco-control.

In addition, a brief synopsis of IPC BPEO is provided in the Appendix for comparative purposes. Further information on IPC BPEO can be obtained from the guidance on the Methodology that has already been published by the Agency.

2.2 Results of analysis of other methodologies

To ensure that the methodologies, which have been developed for different reasons, are reviewed within a common framework, each methodology has been discussed in terms of the following headings:

1. Application - to which basic activities does the methodology apply?
2. Regulation and Certification - what, if any, regulations and/or certification schemes provide the framework and context for the use of the methodology?
3. Scope - does the methodology apply to products, processes, sites or organisations?
4. Boundaries - does the methodology set temporal or spatial boundaries on its use?
5. Prescription - how prescriptive is the methodology?
6. Terminology - does the methodology define specific terms?
7. Methodology - what steps, if any, are prescribed in the methodology?

These headings have been used in this section to compare and contrast the six other methodologies and provisionally identify some of the areas which may prove to be of assistance in augmenting and complementing IPC BPEO.

2.2.1 Application

The application of IPC BPEO, to support the IPC regulatory system, is relatively narrow when compared to some of the other methodologies considered in this review.

The application of environmental impact assessment (EIA) is wide in the issues addressed but is generally understood to be similarly confined to a specific regulatory purpose, i.e. the support of the planning system.

In contrast, life cycle assessment (LCA), environmental management systems (EMS), environmental risk assessment (ERA) and eco-control have a broader application. They have not been formulated to deal with a particular issue and may be applied to address a wide range of problems from strategic policy planning to localised decision making.

2.2.2 Regulation and Certification

Of the seven methodologies considered only IPC BPEO and EIA are based on specific legislation. The use of the former being defined by the EPA 90, the use of the latter by an EU Directive (85/337/EEC) and subsequent UK implementing Regulations.

The other methodologies have no legislative base, although one EMS model has been adopted as the basis for an EU Regulation on an eco-management and audit scheme (the legislative elements of this Regulation require Member States to set up a framework within which industrial sites can voluntarily apply to have their EMS formally recognised).

Despite the lack of a legislative base for the other methodologies, they are all, to a greater or lesser extent, supported by formal guidance and, in the case of EMS and LCA, Certification Schemes. International standards are being adopted for both EMS and LCA and organizations will be able to apply, again voluntarily, for their application of these methodologies to be formally certified or registered.

2.2.3 Scope

The scope of RCEP BPEO covers any "project" but the procedure presented in their 12th report focuses on its application to the prevention and abatement of industrial pollution. The scope of IPC BPEO is constrained to a significant extent by the EPA 90 to a consideration of releases from a prescribed process.

The objective of these methodologies is to identify the best option from a range of alternatives. The other methodologies are more concerned with assessing the impact to be expected from a given process product or operation and in the case of EMS and eco control identifying how best these impacts may be managed. In this sense they have a wider scope than IPC BPEO.

LCA, in theory at least, may be applied to products, processes, site operation or other activities, for example the impact of a service industry. ERA and eco-control have a similar broad scope.

EMS is a "management system" and can be applied at whatever unit of operation is being "managed". It may be constrained to apply only to a specific process or site but may also be applied throughout an organization with many different products, processes and production sites.

2.2.4 Boundaries

Two types of boundary need to be considered, spatial and temporal. The spatial boundaries can be loosely described as local, regional and global without being too prescriptive as to their precise meaning. The temporal boundary can encompass both long term and short term effects but, can also be defined in terms of the product or process life cycle.

The RCEP BPEO methodology goes further into the consequences of products and accidental releases than does the IPC BPEO Methodology. IPC BPEO deals with all "foreseeable" releases although the boundary with accidental releases is not presently clear.

For IPC BPEO local, regional and global environmental effects are taken into account as are long and short-term effects but there is at present no consideration of effects arising from obtaining and transporting raw materials/energy for the process. The example often given to illustrate this is the limestone quarrying and transportation implications of sulphur removal from gas streams and the impacts associated with quarrying and transport versus those of reduced gypsum mining.

The boundaries for LCA and ERA may be set at any point depending upon the activity under consideration. Thus if applied to an IPC process they may consider the source of its raw materials and how they are transported to the process, the source of energy for the process, the

operational effects of the process and the global impact of the products that it produces. At present site specific environmental effects cannot be considered by LCA, instead the relative performance of options is considered in terms of their global environmental effects.

The establishment of assessment boundaries is a considerable technical difficulty in many cases of the application of these techniques. As currently being advocated in the US, ERA is increasingly attempting to involve all interested parties in decision making at all stages of its application. So the assessment of technical boundaries is not treated as a solely technical issue. This trend can also be seen in Europe , for example, in the way that Shell is now testing the BPEO considerations associated with the disposal of the Brent Spar.

The boundaries for EMS are more restrictive than those for LCA and ERA but still require wider considerations than do the BPEO methodologies. For example, EMS requires a consideration of an organization's suppliers and contractors as well as any products and services but does not require as much in-depth analysis as LCA. EMS requires both global and site specific environmental effects to be considered.

2.2.5 Prescription

IPC BPEO is the most prescriptive of the methodologies considered during this study. EIA and the RCEP BPEO methodology are both moderately prescriptive, in that they set out the basic steps to be taken during the assessment - but they do not stipulate specific tasks that must be done to complete each step.

EMS, LCA, ERA and eco-control are all of low prescriptiveness in terms of stipulating the steps to be taken in the assessment, and provide even less guidance on how to undertake the steps. None of the methodologies is very prescriptive when setting out how environmental impacts should be quantified and different impacts compared.

2.2.6 Terminology

Most of the methodologies have specific terminology associated with their use. While there is a broad level of consistency, in some cases very similar terms have different meanings. For example, in EMS there has been considerable debate as to whether environmental effect is the same as environmental impact. These detailed differences do not, however, appear to be major sources of confusion or misunderstanding.

2.2.7 Methodology

The BPEO methodologies are based on a number of well defined, relatively detailed stages, albeit with the RCEP BPEO methodology being presented in less detail than that developed by the Agency.

The less prescriptive LCA, EMS, ERA and eco-control are also based on generally agreed stages but these tend to be less detailed than those associated with IPC BPEO. Since the application of the different approaches is not the same, the methodologies often involve different components.

2.3 Discussion

The review of the other assessment methodologies suggested that none of them offered a 'panacea' to the perceived problems with IPC BPEO. However, there do appear to be some areas where the other methodologies may provide examples of how specific areas of the IPC BPEO Methodology could be further refined. These areas are discussed in relation to each of the other environmental assessment methodologies.

2.3.1 Life Cycle Assessment

Whilst both LCA and IPC BPEO are specifically concerned with the assessment of environmental impacts, they differ greatly in their objectives and scope. Thus, while IPC BPEO is concerned with the effects of releases from a specific process, LCA deals (typically) with a product or service and seeks to encompass all types of environmental effect arising at all stages in the life cycle.

In the area where there is commonality of intent, i.e. in assessing the effects of releases of substances - LCA is less prescriptive than IPC BPEO. In LCA, two main approaches have been used in addressing the releases of potentially harmful substances: Critical Volumes and Eco-Scarcity.

The former approach links most closely with the IPC BPEO approach, inasmuch as the Critical Volume is the volume of the receiving environmental medium necessary to dilute the release to achieve compliance with a relevant environmental quality standard. Thus, by a somewhat different route, the LCA Critical Volume approach uses fundamentally the same type of comparators - environmental quality standards - as does IPC BPEO in assessing the impacts of released substances. The critical volume approach specifically concerns itself with the overall amount of substance released - the load. Whereas the IPC BPEO approach uses concentration, which is generally considered for toxic substances to provide a better indicator of environmental harm than load.

The Critical Volume approach does not appear to offer any potential improvements to the assessment of substance impact under IPC BPEO, as it uses fundamentally the same comparators but in a manner less suited to regulatory impact assessment and control.

The other LCA concept for assessing such impacts, Eco-Scarcity, considers contaminant loads to the environment in relation to national, regional or other goals. It is therefore less obviously related to - and has even less to offer - the IPC BPEO approach as it does not address environmental impact, in terms of site specific environmental concentrations, in a direct way.

Neither does there appear to be any specific advantage to IPC BPEO in the approaches taken by LCA to regional/global issues such as global warming and photochemical ozone creation, since fundamentally the same data (potentials for individual substances) is available to both and used in similar ways.

LCA is inevitably much concerned with the characterisation and assessment of energy and material flows and balances. It would have potentially more to offer IPC BPEO if the scope of the latter were required to be broadened, e.g. to encompass IPPC requirements regarding energy and/or raw material usage.

Finally, it should be noted that sensitivity analysis - referred to specifically in IPC BPEO guidance - is frequently employed as a late step in LCA to identify which of the assumptions made have had the greatest impact on the outcome of the assessment. There is, however, no reason to believe that it provides any major new approaches to, or insights into, environmental sensitivity analysis.

Some applications of LCA have attempted to achieve a fully quantitative assessment of environmental impact by scoring different effect categories such as nutrient releases and global warming. Such approaches have used expert judgements in, for example, Delphi type studies to reach a quantified consensus conclusion. Such studies may be of use in guidance to Inspectors on approaches to comparative assessments notwithstanding the statement in the "Summary Guidance" to the effect that it is not desirable to give universal guidance in this area.

In conclusion, LCA has little or nothing to offer IPC BPEO with its current and particular objectives and constraints. If, however, IPPC were to result in broadening of its scope to include energy usage, LCA offers a framework for addressing that issue.

Recommendation 1: If the Agency were required by DoE to address IPPC requirements, it should consider use of LCA experience in addressing energy usage in particular.

2.3.2 Eco-controlling

Eco-controlling combines elements of the Environmental Management System (EMS) approach and - in particular - the LCA approach with aspects of financial planning and control. In respect of potential support for IPC BPEO and possible extensions thereof, the same remarks apply as for LCA. The technique appears to be used more extensively by companies in mainland Europe than it is in the UK. If it comes to be more widely used in the UK it would be of interest to the Agency as another means of getting companies to integrate more fully environmental considerations into their operating practices.

One of the measures introduced in the Eco-control methodology is called eco-efficiency. Eco-efficiency is relevant in its own right to this report because it is being advocated by organisations such as the World Business Council For Sustainable Development (WBCSD 1996) as one of the key management principles for companies. Basically eco-efficiency means doing more with less but there are seven principles namely:

1. Reduce material intensity of goods and services.

2. Reduce energy intensity of goods and services.

3. Reduce toxic substances dispersion.

4. Enhance material recyclability.

5. Maximise sustainable use of renewables.

6. Extend product durability.

7. Increase the service intensity of goods and services.

Another relevant activity being adopted by some companies is to follow the guiding principles advocated by The Natural Step (The Natural Step International, Newsletter No. 1 May/June 1996). The four system conditions proposed are:

1. Substances from the Earth's crust must not systematically increase in nature. This means that mined materials should not be extracted at a greater rate than they are naturally redeposited.

2. Substance produced by society must not systematically increase in nature, i.e. substances should not be produced at a faster rate than they are broken down in nature or redeposited into the Earth's crust.

3. The physical basis for the productivity and diversity of nature must not be systematically diminished.

4. Energy and other resources should be used in a just and efficient way.

Both initiatives are likely to have broader implications for the Agency in its implementation of IPC, however, at this stage of their development neither has involved the introduction of novel approaches to environmental assessment and they are therefore not considered in any more detail in this report.

2.3.3 Environmental Impact Assessment

It is arguable that, of all the assessment methodologies considered in this study, Environmental Impact Assessment (EIA) is the closest to IPC BPEO.

Like IPC BPEO, EIA is used to support a specific regulatory system (Land Use Planning) with a well defined legal base, and although not normally applied to an individual process, it is site specific. Furthermore, it is similar to BPEO in that it embraces the principle that alternatives to the proposed development be identified and examined, and reasons given for the preferred option. In reality, however, consideration of alternatives has been a weak point of UK EIA implementation (Glasson 1994), the practice being more commonly followed for road and pipeline developments (with respect to alternative routes) than for other types of development.

There are also, however, many significant differences between IPC BPEO and EIA. EIA formalises in relatively broad terms processes of data collection, assessment and reporting, but is far less prescriptive concerning the detailed assessment techniques to be applied (in part no doubt a reflection of the wide range of types of development to which it is applied). Guidance has been issued to aid developers and others in the conduct of EIA and the production of Environmental Statements (ESs), although this too has often been of necessity far broader than that produced in support of IPC BPEO.

Unlike IPC BPEO, EIA looks at the full range of effects associated with the operation of a site, not just those arising from released substances. Thus it covers aspects such as land take, ecology, noise and light pollution, and may therefore provide tools and practical experience more useful to IPC BPEO if the scope of the latter required broadening to meet the requirements of IPPC.

In respect of assessing the impacts of released substances, a requirement common to IPC BPEO and EIA, the latter appears not to have generated any special approaches or insights from which the former could benefit. Indeed, as assessment of such releases in EIA commonly involves a simple comparison with standards or surrogate standards (e.g. derived from toxicological information), it is more likely that the recommended approach to assessment and collated comparator data in IPC BPEO will be used in, and benefit, EIA.

Because there are areas of commonality of intent between IPC BPEO and EIA (HMSO 1992), there is inevitably the potential for duplicated process assessment to be called for when both regulatory regimes are applied. It may therefore be beneficial to foster the use, where appropriate, of the detailed techniques for assessment of substance releases developed under IPC BPEO during EIAs prepared for prescribed processes. This would help to ensure that decisions taken within the two systems are made on the basis of harmonised information, and that the burden on industry is not duplicated needlessly.

Planning Policy Guidance (PPG 23) already defines the high level interaction between planning and pollution control, respectively. Any moves to further integrate IPC BPEO with EIA would therefore have to be undertaken within the framework of this PPG.

Recommendation 2: The Agency should consider ways of fostering the use of the IPC BPEO approach, where relevant, in EIA.

It is of course possible that comparator information collected for EIA purposes could be used for IPC BPEO assessment where there is no EQS or EAL value for a particular substance, but the absence of a mechanism for collating any such information from EIAs will militate against this even if data are available.

Both EIA and EPA BPEO 90 may require, in specific cases, consideration of the environmental consequences of unplanned releases and accidents. IPC BPEO may therefore be able to gain some benefit from EIA experience in this area, although many of the detailed hazard assessment techniques themselves are well established in the general field of process safety.

Guidance, in the context of IPC BPEO, on how to identify, and assess impacts upon, sensitive receptors (e.g. SSSI) has yet to be produced. EIA implementation has provided both guidance on, and extensive experience of, such assessment, and these should be exploited in the production of IPC BPEO guidance on the subject.

Recommendation 3: The Agency should consider expediting the promised publication of specific guidance on sensitive receptors, and use EIA experience where appropriate.

As with LCA, EIA has potentially more to offer IPC BPEO practice if IPPC were to result in broadening of the scope of the latter to include, for example, noise and vibration, as EIA implementation has resulted in the development of guidance, and the acquisition of considerable practical experience, in that and similar "nuisance" areas (e.g. visual intrusion).

Recommendation 4: If the Agency is required by DoE to address IPPC requirements, it should consider EIA guidance and experience when developing assessment techniques for noise and other types of released energy.

2.3.4 Environmental management systems (EMS)

Unlike the other methodologies considered in this section, an EMS is not in itself an assessment methodology (although it does call for a broad assessment to be made of the impacts on the environment of an implementing organisation's activities, products and services).

Rather, it provides a structured framework in which detailed assessment methodologies can be applied, and the results of the assessment used to develop management strategies for reducing and controlling the identified impacts.

To the extent that EMS is not itself an assessment technique, it has little to offer IPC BPEO with regard to detailed mechanisms of assessment. Management system principles and practices are, of course, of great importance in ensuring that processes are operated effectively within the constraints required by legislation and regulations - but this is of concern to IPC in general, and not specifically to IPC BPEO. The definition of 'techniques' within BATNEEC already makes allowance for management issues when setting authorisation conditions, although the use of EMS, particularly if based on a widely accepted standard, may allow a more systematic judgement of the acceptability of the operator's proposals.

As with EIA, experience gained through EMS implementation of such areas as assessment of "nuisance" factors and hazards arising from non-routine and emergency conditions may prove helpful in IPC BPEO. However, as EMS is a younger technique than EIA, it has tended itself to adopt practices from that discipline - and, indeed, from IPC BPEO in respect of release assessment.

However, the practices within EMS of using simple ranking systems and comparing corporate or site contributions to regional or global effects (e.g. global warming) with national or sectoral figures, on a normalised basis (e.g. turnover/GDP) may have applications in IPC BPEO.

Thus, for example, it is recommended that the Agency consider developing weighting factors to be applied (non-mechanically) to the numerical values for the different areas of environmental impact (IEI, GWP, POCP, WHS). Such weighting of different impact areas has been applied in EIA, LCA and EMS, and could help to emphasise the relative importance of different types of impact and aid consistency of interpretation amongst Agency staff.

Moreover, normalised comparisons with national figures (e.g. for GWP and POCP) could help the development of relative weightings for these factors.

Recommendations 5: The Agency should consider developing weighting factors - to be used in a flexible, rather than mechanical, way - for different effects (i.e. for IEI, GWP, POCP and WHS). The Agency may also consider the use of normalised comparisons with national production data when developing weightings.

Management system principles are, however, also important to the sound conduct of the IPC BPEO process itself - for example, in providing data, and in helping to ensure that the process operator's option generation, screening and assessment is properly planned, executed and documented, and can be audited by Agency staff. Therefore, site operation within the framework of a sound EMS model (e.g. BS 7750, ISO 14001 or EMAS) should help operators to ensure that their IPC BPEO work is efficiently conducted and to render them less vulnerable to time-consuming and expensive re-working at a late stage in the process.

Additionally, the use of an EMS should help to ensure that the operator keeps abreast of the environmental dimensions of technical and other developments, thereby facilitating the efficient identification, screening and assessment of process options from an early stage.

Finally, the practice of developing Sector Application Guides (SAGs) to help specific industrial sectors implement particular EMS Standards (e.g. BS 7750) has obvious parallels with the concept of IPC BPEO sector guides. It should be noted, however, that the comprehensiveness and detail of the EMS SAGs produced to date varies quite widely, and some contain very little detailed guidance.

2.3.5 Environmental Risk Assessment

Environmental risk assessment (ERA) is not a specific methodology and as such has little to offer IPC BPEO in specific terms, such as comparing impacts across media. The concepts of risk, however, are of major importance to the assessment process, for example, risks of releases, risks of exposure of targets and risks of effects are all implicit in the IPC BPEO Methodology. The explicit recognition of risk in the assessment of the impact of short term and foreseeable but unplanned releases would make decision making easier but inevitably make the methodology more complex. Similarly putting the methodology onto a risk basis would avoid the need for arbitrary boundaries associated, for example, with "significant" releases. There is therefore much that could be used to modify the Methodology but at the expense of added complexity. These changes are not currently recommended but may be desirable medium term targets and suitable techniques for their application should be developed.

The area where ERA, as currently being considered in the USA, is probably of most relevance to the IPC BPEO Methodology is in relation to the implied boundary between technical assessment and societal values (AIHC 1996). The Methodology, for example assumes that "significance" is a technical issue of definition. Current thinking about ERA is that all environmental judgements are at least partly social and therefore require a societal input if they are to be successfully implemented. It is interesting that Shell have reached similar conclusions following the Brent Spar incident. The lesson for the Agency in relation to IPC BPEO seems to be that for major authorisations likely to attract significant public interest then start the public involvement at the earliest possible stage in the process.

2.3.6 RCEP BPEO

The RCEP was at the fore front of developing a methodology for identifying the BPEO. In developing its own BPEO assessment methodology to support the IPC regime, HMIP (now the Agency) drew extensively on the work of the RCEP to the extent that there is little or no difference between the two methodologies. The RCEP BPEO methodology is not as detailed as that developed by the Agency, nor was it intended to be. In this sense the use of the RCEP's BPEO methodology can be said to be 'exhausted' as a means of informing the development of the IPC BPEO Methodology.

3. CASE STUDIES

3.1 Introduction

To facilitate the project, a number of IPC BPEO case studies relating to existing processes were reviewed to aid in the identification of strengths and weaknesses in the application of IPC BPEO.

The IPC Public Registers in each of the Agency's eight Regions were contacted in an attempt to identify whether or not any IPC BPEO assessments had been undertaken and submitted to the Agency. A number of references were identified on the Registers, none of which involved the use of the IPC BPEO Methodology, but these invariably addressed the issue in a perfunctory and often inappropriate manner, suggesting that in the absence of the Agency's Methodology industry would have little understanding of the concept or the benefits it can deliver.

In the absence of examples of how the IPC BPEO Methodology had been applied in real situations it was decided to utilise the case studies the Agency had previously commissioned. These case studies applied the IPC BPEO Methodology to real processes, albeit in situations where the proposed alternative control options were hypothetical. Because of this constraint, there were limitations in the usefulness of the case studies in illustrating the strengths and weaknesses of the IPC BPEO Methodology, in particular none of the available case studies considered process options, instead they concentrated on generating and assessing control options.

The case studies covered the following prescribed processes:

- polymer and paint manufacture;
- steel manufacture from scrap;
- acetylene and lime manufacture;
- the refining of non-ferrous metals;
- operation of a coking plant;
- power generation; and
- sewage sludge incineration.

Only two other full BPEO assessment were identified and used in this study.

The first assessment was prepared by North West Water (NWW 1994) using a methodology developed by WRc for HMIP (WRc 1990). This assessment was undertaken by NWW to identify an alternative to its present strategy for sewage sludge disposal, sea dumping, which will be banned from 1998. The second assessment was that prepared by Shell in support of the planned disposal of the Brent Spar Oil Platform. As with the NWW assessment, this did not

relate to a prescribed process and so was in no way constrained in the types of effect that could be considered during the assessment. However, in the absence of other assessments they provided examples of situations where real 'process' options had been considered and an alternative approach to the IPC BPEO Methodology adopted. Both were in fact instructive in a number of areas, most notably the generation and screening of options and the overall presentation of the assessment.

The main issues arising from the case studies and their implications for any proposed revision of the Agency's methodology are discussed below under the following headings:

1. The legal base of IPC BPEO.

2. The releases covered by an IPC BPEO assessment.

3. The availability of data to support the assessment.

4. The format of IPC BPEO guidance.

5. The generation and screening of options.

3.2 The Legal Basis for IPC BPEO

Section 7(2) of the Environmental Protection Act 1990 (EPA 90) outlines the objectives that must be met by the Environment Agency (the Agency) when setting conditions in authorisations for Integrated Pollution Control (IPC). Section 7(7) further requires that where a process is one designated for central control and likely to involve the release of substances into more than one environmental compartment then a further objective must be complied with. This objective is to ensure that BATNEEC will be used to minimise pollution which may be caused to the environment taken as a whole by releases having regard to the best practicable environmental option (BPEO) (hereafter referred to as IPC BPEO to differentiate it from other forms) as respects the substances which may be released.

This precise definition of IPC BPEO in the EPA 90 has caused some confusion and this lies at the heart of a considerable amount of the criticism levied at the methodology. The confusion probably stems from the widespread perception that IPC BPEO is one and the same as the Royal Commission on Environmental Pollution's (RCEP) vision of what constitutes BPEO. In terms of their application these two respective approaches to BPEO assessment are very different, but this has not prevented the confusion and subsequent criticism arising. In addition the term best practicable environmental option has since been used even more widely, for example in the debate about the disposal of Brent Spar, and has thus attracted a broad and indeterminate meaning which raises expectations that a wide ranging consideration of environmental impacts and issues will be addressed in any "BPEO" study. These expectations will often exceed the regulatory scope of IPC BPEO.

The RCEP outlined a BPEO methodology in its broadest sense. They provided a carefully reasoned exposition of an innovative approach to protecting the environment from any project or activity that may affect it. The RCEP was not required, nor in practice did it intend, to constrain its methodology by defining what substances and environmental effects could or

could not be covered by its methodology. The Agency has not had this latitude in developing its approach, with its Methodology being legally confined by the EPA 90 to a consideration of pollution caused by releases from prescribed processes.

Because of the very detailed statutory requirements of the EPA 90 the Agency's Methodology cannot be critically compared and contrasted with the RCEP's methodology at a very detailed level. A comparison of the underlying concepts and practices, however, shows a high degree of commonality between the two methodologies, particularly now that the Agency's summary guidance has dropped the identification of the best environmental option (BEO), a step the RCEP never considered.

In view of the wide differences between the various uses of the term BPEO it would be sensible for the Agency to manage expectations by emphasising that its use of BPEO in relation to prescribed process authorisations is that specified in EPA 90. This may be done at several levels. For example, whenever the Agency's methodology is referred to, whether in the specific supporting guidance or in more general documentation, the term BPEO could be prefixed, as in this report, by the phrase 'IPC'. In addition, the introductions to both the Agency's summary and full guidance on its methodology could more clearly make a statement to the effect that

> 'the Agency has developed an IPC BPEO Methodology to serve the specific requirements of the IPC system. This methodology has drawn on the general principles of BPEO set down by the RCEP but has been further developed by the Agency to meet its own regulatory needs.

Recommendation 6: The Agency should consider developing a strategy to clearly differentiate between its use of the term BPEO and that used more widely and sometimes loosely in other contexts.

The Environment Act 1995 has provided the Agency with a sustainability duty (DoE 1995a). The current IPC Function Strategy, recently produced by the Agency for consultation, appears to conclude that the application of the IPC BPEO requirement in IPC will "ensure a sustainable outcome for the environment as a whole". In view of the restrictions within which IPC BPEO works, this statement may be difficult to sustain and some additional guidance may be needed for Inspectors who will have to grapple with the complexities of this situation.

Recommendation 7: The Agency should consider clarifying the relationship between the IPC BPEO Methodology, with its limited considerations of environmental effects, and the sustainability duty of the Agency and provide appropriate guidance.

A similar clarification of the general duties placed on the Agency in Section 7 of the Environment Act 1995 may also be required with respect to IPC BPEO. In particular Section 7(1)b places a duty on the Agency when formulating or considering any proposals relating to its pollution control functions to have regard to the desirability of conserving and/or enhancing natural beauty, flora, fauna and geological or physiographical features of special interest. Given that IPC BPEO relates only to releases from a process, such a clarification is likely to concentrate on conserving flora and fauna. In addition, implementation of the Habitats Directive may require the provision of additional guidance to Inspectors to help them interpret the interaction between IPC BPEO and the Directive's provisions.

Recommendation 8: The Agency should consider clarifying the relationship between the IPC BPEO Methodology and Section 7 of the Environment Act 1995 and the Habitats Directive, respectively.

3.3 The Environmental Effects covered by an IPC BPEO Assessment

As outlined above, the EPA 90 provides a statutory framework for the way in which the IPC BPEO Methodology is utilised. Part I of the EPA 90 defines pollution to the environment as (our bolding):

> 'pollution of the environment **due to the release** (into any environmental medium) **from any process** of substances which are capable of causing harm to man or any other living organisms supported by the environment'.

The Agency's methodology has therefore been restricted to a consideration of the environmental effects associated with **releases** from various process options. To this extent, one of the main criticisms of IPC BPEO, that it looks at only certain environmental effects associated with a process, is entirely unfounded. Although the RCEP methodology suggests that the identification of the BPEO should be based on a wide range of effects, for example issues such as communication links and raw material sourcing for the process, this has no relevance to the statutory requirements of the Agency's methodology.

Although, such criticism of the scope of effects covered by the IPC BPEO Methodology is relatively easy to refute, the Agency's Methodology notes, specifically in Section 7.8, that the guidance is not fully comprehensive in terms of all types of releases that may need to be assessed. Section 7.8 of the Agency's Methodology states that:

> 'The factors outlined in Sections 7.3-7.7 (long term effects, global warming, waste hazard scores etc) are neither exhaustive nor exclusive. Other additional factors might be pertinent to any particular process at a specific location. In particular, the following factors: odours, visible plumes, dioxins and furans, exceedance of critical loads and foreseeable, but unplanned releases.'

A number of the case studies involved an assessment of the effects associated with odours but in general, unless there was specific guidance in the Methodology, no attempt was made to assess the effects associated with a release. Thus two of the case studies noted that the release of dioxins may be factors but that in the absence of any guidance from the Agency, no attempt would be made to assess the potential effects of such releases. This would suggest that although the Agency has made it clear in the guidance that other releases may be relevant, unless there is specific guidance from the Agency on how the assessment should be done, then it is unlikely that they will be considered during the preparation of an IPC BPEO assessment. It is noted in Section 7.8 of the Methodology that the Agency is developing guidance for a number of these other type of releases. It would be of benefit if this additional guidance was made available as soon as possible.

Recommendation 9: The Agency should consider expediting the development of guidance referred to in Section 7.8 of the IPC BPEO Methodology that relates to other types of releases, for example dioxins, visible plumes (including steam and water vapour) and critical loads.

Section 5.10 of the Methodology covers potential impacts on sensitive receptors. None of the case studies identified any relevant sensitive receptors in their environs and therefore no useful information can be drawn from this source.

However, until the Agency develops better guidance in this area it is unlikely that many assessments will address such impacts. For example, the Agency indicates that a Site of Special Scientific Interest (SSSI) could be considered as a sensitive receptor but provides no guidance on how close to the process it would have to be to be a factor. Some types of SSSI may only be sensitive to releases from a process when they are in the immediate vicinity (less than one mile) of the site but others, for example those susceptible to acid deposition, maybe many tens of miles away.

Recommendation 10: The Agency should consider developing guidance on sensitive receptors, including some form of screening process for identifying when they should be considered in the assessment as well as guidance on how the actual assessment should be done.

One other factor relating to sensitive receptors may merit attention. Section 5.10 of the Methodology suggests that 'particular substance/receptor combinations such as the effects of fluoride on cattle' may merit assessment. This is an extremely complex area that would in itself demand extensive guidance and it is highly unlikely that a process operator would consider potential options in this manner unless prompted by the Agency. The Agency may therefore feel that its Inspectors need explicit guidance on where such situations may occur. Note: the specific example of a substance/receptor combination, fluoride and cows, is probably an inappropriate one for IPC BPEO. This problem, quoted in the RCEP's 12th report, arose from the transfer of fluoride to the cow population via the pathway:

> release to air - transfer to aqueous phase via wet scrubbing - transfer to the solid (sludge) phase via waste water treatment - transfer to land via sludge application - transfer to the cow via ingestion of sludge contaminated grass.

The constraints of the EPA 90 mean that the Agency cannot dictate what route is selected for the disposal of waste, in this case the sludge, and nor can it consider the indirect environmental effects arising from the process operator's chosen disposal route. However, the analogy may be more appropriate if it was considered that the fluoride was discharged to air and thence deposited on land upon which the cow was grazing.

Recommendation 11: The Agency should consider the implications of requesting that process operators consider substance/receptor combinations. If appropriate it should consider providing inspectors with guidance on what combinations may cause problems. The Agency should also consider the appropriateness of the substance/receptor example it provides, in its present form the example could be misleading about the scope of IPC BPEO.

Section 7.8 provides a recognition that the IPC BPEO Methodology is still incomplete in terms of the guidance it provides on how releases should be assessed. It notes that further guidance will be developed for other types of release. However, a consideration of the Case Studies suggested that there may be yet more releases for which assessment guidance is required. Four types of release give rise to particular concern. These are:

- foreseeable but unplanned releases;
- releases of energy;
- releases to sludge via sewer; and
- ozone depleting substances.

Legal advice may be required as to whether these releases can be covered by the IPC BPEO Methodology, in particular because of the pending implementation of the Directives on Integrated Pollution Prevention and Control (IPPC) (CEC 1996) and Control of Major Accident Hazards (COMAH), respectively.

3.3.1 Foreseeable but unplanned releases

None of the case studies considered the potential effects arising from foreseeable but unplanned releases, although this is perhaps not surprising given that they were based solely on an assessment of control, rather than process, options. Section 7.8 of the Methodology notes that the Agency is developing guidance to address such releases but before this task commences it may be appropriate for the Agency to clarify what constitutes a 'foreseeable but unplanned release'.

Section 7.8 of the IPC BPEO Methodology provides examples of such releases as those from 'safety valves or overflows'. This would suggest relatively minor releases, possibly resulting in, for example, the exceedance of short term EALs but probably not major long term harm to the receiving environment. If this were the case, an assessment of the potential harm associated with an option would be relatively simple, involving the, consideration of generic failure frequencies, modelling of the maximum possible quantity of substance that could be released and a comparison with the short term EAL.

However, if a 'foreseeable but unplanned release' is taken to mean any type of accident, potentially including a major release to the environment then both the process operator and inspector may have to make some type of judgement about the relative importance of routine and non-routine releases arising from an option. For example, one option may apparently be the site specific IPC BPEO due to its relative insignificant routine release. However, the site's proximity to a major, vulnerable aquifer and the option's reliance on the storage of large amounts of hazardous chemicals, which may potentially be released during an accident, could cause the option to be rejected in favour of one with higher routine releases but with less scope to cause harm during an accident.

The Department of the Environment (DoE) has issued guidance on 'The Interpretation of Major Accident to the Environment for the purposes of the CIMAH Regulations (DoE 1991). This guidance may be of use to the Agency if it decides to require a more detailed assessment of the potential environmental effects associated with major accidental releases from various process options. The DoE guidance defines a major environmental accident in terms such as the following:

> 'Permanent or long term damage to a national nature reserve, a SSSI (including watery habitats), a marine nature reserve (statutory or voluntary), or an area protected by a limestone pavement order, resulting in loss of scientific interest (i.e. loss of nature conservation value) in:
>
> - more than 10% or 0.5 hectares (whichever is the lesser) of the area of the site, or
>
> - more than 10% of the area of a particular habitat, or
>
> - more than 10% of a particular species associated with the site.

For other habitats the following figures are used - 2 hectares of a scarce habitat (e.g. fens), 5 hectares of intermediate habitat (e.g. salt marsh) and 10 hectares of more widespread habitat not otherwise classified.

Similar criteria are used for damage to the man-made environment, e.g. damage to a Grade 1 listed building or a scheduled ancient monument. The guidance also covers indirect effects, e.g. the loss of at least 10 hectares of agricultural land, the loss of a water supply for more than 10 000 people.

Options could then be compared in terms of their potential to give rise to such major environmental accidents.

A similar approach was adopted by the National Rivers Authority (NRA) in developing its Groundwater Policy (NRA 1992). The general potential for harm of a process was linked to the importance and vulnerability of aquifers. This enabled the NRA to broadly screen proposed developments for their general acceptability, for example, the combination of high polluting potential, vulnerability and important aquifer would result in the NRA opposing a proposed development. The NRA also applied for the Dee Water Protection Zone which required a consideration of the storage of hazardous chemicals in a sensitive catchment.

It is possible that some of the lack of clarity about how environmental effects associated with accidental releases should be considered merely reflects the need for wider integration of environmental protection with health and safety. It may be appropriate for the Agency to set up a joint working party with other interested parties in this area (Health and Safety Executive, Local Authorities and Industry) to exchange ideas on how such effects can best be assessed. The Agency is likely to be joint implementing authority, with the HSE, for the new Control of Major Accident Hazards (COMAH) Directive and this may facilitate such a joint working party.

Recommendation 12: The Agency should consider clarifying the types of 'foreseeable but unplanned release' that it would expect a process operator to cover during an IPC BPEO assessment and develop guidance accordingly.

Recommendation 13: The Agency may consider it appropriate to set up a joint working party with the Health and Safety Executive, Local Authorities and Industry to refine the approaches adopted for assessing the potential environmental effects associated with accidental releases.

3.3.2 Releases of energy

The EPA 90 defines substance as follows '...substance shall be treated as including electricity or heat ....'. None of the case studies assessed the release of heat to the environment, although given the type of processes they covered this is perhaps not unexpected. However, in view of the reluctance of the case studies to address releases in the absence of guidance from the Agency, it may be beneficial for the Agency to develop an assessment technique for considering the heat releases from options.

Environmental quality standards (EQSs) have been set for the temperature of receiving waters. For example, the Surface Water Intended for Abstraction for Drinking Water Purposes (75/440/EEC) (CEC 1975) provides two EQSs (22 °C and 25 °C), although these only apply in designated waters. Similarly, the Freshwater Fisheries Directive (CEC 1978) states that:

> (for the protection of salmonid fisheries) thermal discharges must not cause a rise in temperature of more than 1.5 °C (although limited derogation may be provided) and (except under very unusual meteorological conditions or geographical conditions) should not raise the temperature of the water above 21.5 °C or 10 °C during the breeding of species which need cold water for reproduction. These standards are expressed as 98-percentiles.

Less stringent EQSs are set for cyprinid fish.

It is less clear what implications the EPA 90's definition of 'electricity' as a substance has for IPC BPEO. The legal definition of IPC BPEO constrains it to a consideration of releases but it is difficult to envisage what constitutes a release of 'electricity'. The definition in this form may contribute to the confusion about the scope of IPC BPEO and the need to clearly differentiate it from the broader aspirations of RCEP BPEO. This may need further consideration in respect of both IPC BPEO and BATNEEC.

Annex IV of the IPPC Directive lists a number of factors to be (generally) taken into account when deriving BAT. One of these factors is the energy efficiency of process options. Implementation of the Directive may require the Agency to modify its IPC BPEO Methodology such that electricity consumption by a process option becomes a factor in the assessment. There appears to be no suggestion in the Directive that electricity use should be linked to indirect releases associated with its off-site generation.

The Directive also defines an emission in terms of other types of energy, including vibration, noise and heat. The Agency may need to develop guidance to address the effects associated with such releases.

Recommendation 14: The Agency should consider clarifying the types of 'energy' beyond electricity and heat that could be covered by an IPC BPEO assessment and develop guidance appropriately.

3.3.3 Releases to sludge via sewer

In recognition that discharges to sewer usually receive some form of treatment prior to release to the aquatic environment, the Agency has introduced the concept of the sewage treatment reduction factor (STRF). Section 6.5 of Volume III to the IPC BPEO Methodology outlines the basic principle behind this concept. The guidance suggests that an STRF of 0.6 may be appropriate when calculating the actual release to the environment, i.e. the sewage treatment process removes on average 40% of the pollutant load, the remaining 60% being discharged to the aquatic environment as if the waste water had been released untreated from the process.

This approach would raise no real concerns if sewage treatment genuinely reduced the polluting potential to the environment as a whole of the substances involved. However, for some substances the sewage treatment process merely re-partitions the substance from the aqueous phase to the solid phase (i.e. sewage sludge). This is particularly the case for heavy metals and persistent organics, substances that have the greatest potential to cause harm to the environment. The resulting contaminated sludge must then be disposed of (to landfill, incinerator, agricultural land etc). In effect the treatment process does not 'destroy' the polluting potential of the substance it merely re-directs it to another environmental compartment. Such a transfer of pollution was one of the primary reasons why the RCEP developed the concept of BPEO. The Agency may therefore consider it appropriate to investigate ways in which the anomaly can be addressed.

Of course, the EPA 90 prevents the Agency from considering the effects associated with the off-site disposal of waste. However, the concept of the unit hazard score was developed to ensure that at least some form of assessment was made of the wastes arising from an option but which, because they were not released directly to the environment from the process, could not be considered during the generation of the environmental quotients. The Agency may consider it appropriate to require certain substances (heavy metals and persistent organics) that are assumed to be removed by sewage treatment to be assessed via their incorporation into the generation of the unit hazard score.

The Agency may also consider it appropriate to assess whether sludge generated by the on-site waste water treatment that is not part of the process should be assessed in the same manner.

Recommendation 15: The Agency should consider whether it is appropriate to include certain substances assumed to be removed by sewage treatment in the unit hazard score for a process.

3.3.4 Ozone depleting substances

None of the case studies reported giving rise to releases of ozone depleting substances, although given that such releases are not covered by the IPC BPEO Methodology this is perhaps not surprising.

Although the Montreal Protocol is leading to the phase out of the most harmful ozone depletors, many less harmful substances are still in use, it may therefore be helpful for the Agency to briefly outline in the IPC BPEO Methodology why ozone depleting substances are not to be covered by an assessment.

Recommendation 16: The Agency should consider clarifying its approach towards the assessment of ozone depleting substances using the IPC BPEO Methodology.

3.4 Technical data

Two issues arose from the case studies relating to the use and availability of technical data upon which IPC BPEO assessments are based. These were:

- the use of comparator values;
- the availability of data on ambient concentrations.

3.4.1 Comparator values

The Agency's methodology makes use of a large number of comparator values to enable the level of harm associated with a particular process to be assessed. These comparators include environmental quality standards (EQS), environmental assessment levels (EALs), Unit Hazard Scores (UHS) etc. These are presently listed in Volume III of the Agency's IPC BPEO Methodology for a number of substances.

Difficulties arose in all of the case studies from the lack of suitable comparator values against which the harm associated with options could be assessed. Where a comparator was not available for use in the case studies no attempt was made to either derive a surrogate or provide at least a basic discussion of the release and what implications its exclusion from the assessment may have for the final identification of the IPC BPEO. The Agency may consider that it is appropriate to provide more explicit guidance for process operators on what to do in such situations. For example, by encouraging them to derive their own surrogates and suggesting that a discussion be provided of those releases not considered in the assessment - composition data could at least be provided on solid wastes. Of course, the derivation of surrogates for comparators would not be an easy task, particularly for UHSs where up to nine different types of information may be needed to derive the comparator and/or complex structure activity modelling undertaken. The Agency may therefore consider it appropriate to identify in its guidance on IPC BPEO a source within the Agency which process operators could approach for assistance in deriving surrogate comparators.

Clearly there are many thousands of substances that could be released from a process and given the finite availability of resources, it would be an impossible task to develop comparator values for all releases. However, the Agency may consider it appropriate to identify areas where there appear to be particular deficiencies. For example, very few UHSs were available and this caused major problems in virtually all of the case studies. It may therefore be appropriate to prioritise the development of further UHSs.

A further consideration in this area is the pending implementation of the IPPC Directive. The implementation of the Directive may involve an expansion of the number of prescribed substances covered by the UK IPC system. A consideration of such prescribed substances is particularly important in undertaking an IPC BPEO. The Agency may therefore consider it appropriate to ensure that a programme is in place to develop comparator values for all substances that may be newly prescribed as a result of the adoption of the Directive.

In at least two of the case studies problems arose due to the availability of more than one comparator for the release of a substance to a specific medium. In particular, it was not always clear why one environmental assessment level (EAL) from several had been selected to be the comparator for the release of a substance to the aquatic environment. Further guidance may be needed to ensure that process operator's understand which EAL to use and record their reasoning in the assessment. For example, by outlining how an EAL for a substance may vary depending on the designation of the receiving waters (fisheries, bathing water, drinking water abstraction etc) and physico-chemical properties (hardness etc). In situations where the receiving waters have no designation, guidance should be provided on which EAL to use as a default during the IPC BPEO assessment.

Recommendation 17: The Agency should consider providing further guidance on how an IPC BPEO assessment should address the lack of comparator values.

Recommendation 18: The Agency should consider prioritising the development of new comparator values. For example, on the basis of areas where the case studies have shown there to be particular problems (i.e. UHSs) as well as to ensure that comparator values are available for any newly prescribed substances.

Recommendation 19: The Agency should consider providing guidance on how to identify one of several possible comparators to address a particular problem.

3.4.2 Ambient concentrations

The prioritisation of releases for control relies on the availability of data on ambient concentrations.

All of the case studies were constrained by the lack of data on ambient concentrations. In a number of cases no data were available against which an assessment could be made, for example no information was available on levels of suspended solids in the Tyne Estuary. In some cases, information from other sites, often bearing little or no relation to the one for which the assessment was being done, had to be used.

The Environment Agency is playing a part in the Environmental Analysis Co-operative (EAC) which through publication of the Released Substances and their Dispersion in the Environment (RSDE) document is helping to disseminate information on the sources of this type of data. The EAC has a project underway on ambient concentrations but the Agency should consider whether this project has an appropriate scope and timetable to meet its needs relating to IPC BPEO.

Recommendation 20: The Agency should consider the scope and timetable of the EAC project on ambient concentrations for its implications for IPC BPEO.

As and when more examples of real IPC BPEO assessments become available they should be critically appraised to identify if there are any recurring problems that may need to be addressed as a matter of priority.

The case studies indicated that there was a certain degree of confusion over the response to be adopted in the event of an EAL being exceeded. In a number of cases statements were made to the effect that 'the small contribution of the process to the exceedance of the EAL means that further consideration of this release is not justified'. Such statements may well be accurate but it should be for the Agency to make the decision. No recommendation is made on this issue but it may need to be considered further in the future.

3.5 IPC BPEO Guidance

The case studies suggested that there are a number of areas in which the format and style of the IPC BPEO Guidance could be improved. These areas are:

1. Clarification of the link between BATNEEC and IPC BPEO;

2. The development of more 'user friendly' guidance.

Each of these issues is discussed in more detail below.

3.5.1 Clarification of the link between BATNEEC and IPC BPEO

BATNEEC and IPC BPEO reflect, in essence, the two fundamental approaches to the control of pollution by hazardous substances, namely Emission Limits and Quality Standards, which have been much debated within the European Union.

In EPA 90, the BPEO concept is directly subordinate to BATNEEC - the wording being "BATNEEC ... having regard to BPEO", with IPC BPEO being required when there may be releases to more than one medium. Neither RCEP BPEO nor any of the other environmental impact methodologies operate within such a "technique limited" framework. It follows that there is little to be learned from other methodologies or approaches regarding this specific aspect (i.e. the subordination of BPEO to BATNEEC within the present regulatory framework).

However, in considering the case studies, and as a result of discussions with Agency staff during the conduct of this study, a number of issues have emerged concerning the relationship between BATNEEC and IPC BPEO.

Guidance on BAT is given in IPC Guidance Notes (formerly Chief Inspectors Guidance Notes) for particular categories of prescribed processes, whereas IPC BPEO is a site specific assessment of impacts of releases. The assumption is implicit that in a specific case there will be more than one BATNEEC option and that application of IPC BPEO will help determine which option is "best" (i.e. in terms of IPC BPEO) for a particular site.

Since application of BATNEEC is to be followed by application of IPC BPEO, it seems logical that any guidance should follow the same sequence - guidance on IPC BPEO following guidance on BATNEEC provided by the IPC Guidance Notes. This is not currently the position, with the guidance on the two concepts being presented separately.

Process Guidance Notes do provide a brief commentary on IPC BPEO and associated issues but the manner in which they do it is brief and in some ways confusing. For example, Paragraph 2.1.3 of Process Guidance Note IPR 4/1 - Petrochemical Processes states that '..it should be borne in mind that marginal reduction in releases of substances by the use of high energy technology could result in an overall increase in releases' (HMSO 1993). However, any such increase in releases is going to occur at a point remote from the process, whether it be at an off-site power station, or at a on-site power station that is covered by a separate authorisation. In this sense, the Process Guidance Notes perpetuate the lack of clarity about the scope of IPC BPEO.

Possible solutions include modifying the existing IPC Guidance Notes to refer to IPC BPEO, or the production of a single guidance document covering both BATNEEC in general and IPC BPEO. This might help to address general criticism relating to the complexity of IPC BPEO assessment.

Recommendation 21: The Agency should consider clarifying the link between BATNEEC and IPC BPEO.

Recommendation 22: The Agency should consider whether the present format of its guidance on BATNEEC and IPC BPEO, respectively, is mutually supportive. If the present format is retained, consideration should be given to reviewing the IPC Guidance Notes to ensure that they adequately address IPC BPEO and do not make any statements that could be perceived as conflicting with its requirements.

The IPC BPEO case studies were undertaken to inform the Agency on the strengths and weaknesses of its Methodology. Within their limitations, the assessment of hypothetical control options for existing processes, these case studies have provided some useful information on how the Methodology could be further developed. However, until IPC BPEO assessments commonly include process, rather than control, options then there will be limitations in the lessons that can be drawn from the Methodology's practical application. The Agency may consider it appropriate to address this deficiency by critically appraising an IPC BPEO assessment where an operator is seeking to make a real process variation or introduce an entirely new process.

Recommendation 23: The Agency should consider identifying a suitable case study for a real process variation/new process where process options have been genuinely considered and using it to critically assess its current IPC BPEO Methodology.

3.5.2 The Format of the Guidance

The IPC BPEO Methodology is a complex assessment technique that necessitates the use of comprehensive guidance. At present this guidance is only available in 'hard' copy, it is apparent from extensive use of the guidance throughout this study that the development of an 'electronic' version may offer significant advantages to those utilising it during an assessment.

For example, a hyper-text version of the guidance would allow rapid movement between related topics. Thus there are several references to the assessment of significance in the guidance, ranging from a discussion of the basic principles to the provision of the detailed methodology on how to do the task, but without an intimate knowledge of the various annexes it can be time consuming and frustrating in moving between the related areas.

In the longer term, the Agency may wish to further develop the IPC BPEO Methodology by producing an electronic template for the assessment. The process operator would provide the necessary data and the proforma would automatically identify significant releases/priorities for control. A help facility could be constructed for each element of the template, in many ways mirroring the guidance. Such a development could greatly facilitate the examination of the application by Inspectors by enabling simple consistency and quality checking to be done automatically. It may also facilitate the technical evaluation by ensuring that key process or location factors are identified and allowed for in the application.

Recommendation 24: The Agency should consider developing a hyper-text version of its IPC BPEO Methodology.

Recommendation 25: The Agency should consider the long term development of an electronic template to guide process operators undertaking an IPC BPEO assessment.

The case studies did suggest that there are enough sector specific aspects to the preparation of IPC BPEO assessments to merit considering the development of Sector Specific Guidance. The Agency is already developing Best Practice Guides on how specific sectors could undertake an IPC BPEO assessment, it may be possible, in the longer term, to further develop this concept.

Recommendation 26: The Agency should consider whether the Sector Specific Best Practice Guides it is presently developing in support of IPC BPEO could be expanded to address more general issues pertaining to the use of the assessment methodology by that sector.

3.6 Options

The main issues arising from the case studies relating to the management of options in identifying the IPC BPEO were:

- the generation, screening and assessment of options; and
- the identification of the 'best practicable' environmental option.

Each of these issues is discussed in more detail below.

3.6.1 Generation, screening and assessment of options

The robust generation, screening and assessment of options is perhaps the most crucial element of the whole IPC BPEO Methodology. As the RCEP noted in its 12th Report "no amount of detailed evaluation will identify the 'best' solution if the 'best' option is not included in the initial set".

The case studies were not, however, particularly informative on this issue. As alluded to earlier, the case studies relied upon the generation of hypothetical control options for existing processes which, in reality, were not to be varied or replaced.

One general issue that did arise was the way in which the options were presented. Benefit could have been gained from a pictorial representation of the options in the form of flow diagrams, with particular emphasis on how they differed from each other. These flow diagrams could have been developed into mass balances to indicate the main releases from each option. The Agency is in the process of developing Best Practice Guides and may consider it appropriate to use these to encourage greater use of pictorial representation of options.

Recommendation 27: The Agency should consider promoting greater use of pictorial representations of options.

The systematic generation, screening and assessment of options is in practice not widely used in assessment methodologies aside from EPA 90 BPEO despite the implicit or explicit requirements associated with the use of these methods.

Guidance issued to support the use of environmental impact assessment (EIA) encourages developers to discuss alternatives but in the practical application of the guidance the large majority of assessments concentrate on the developer's preferred option. Thus EIA tends to be used as a mechanism for outlining the facts relating to a proposed development to aid the decision making process rather than to encourage, in the RCEP's words applied to BPEO 'a diligent and imaginative search for alternative ways of achieving the desired result'.

Life cycle assessment (LCA) suggests, by implication, that alternatives to achieving a desired result exist and are considered. However, to date, LCA has not involved the preliminary identification of many options, their screening and then the application of the full assessment methodology to two or three preferred options. Instead most practitioners have by-passed the initial generation and screening stages and passed straight on to applying the assessment methodology to the few options that they believe merit detailed consideration.

None of the alternative approaches to BPEO are based on a systematic approach to option generation and screening. However, Shell suggested a set of factors against which options could be screened for their particular purposes. Thus, in identifying viable options for the disposal of the Brent Spar, Shell applied the following factors:

- engineering complexity;
- safety and risk;
- environment and resource use;
- acceptability (to Governments, Regulators and other interested parties); and
- cost.

In the most recent draft of the IPC BPEO methodology, specifically Section 6.13, the Agency suggests that options should initially be screened against the following factors:

- familiarity with particular techniques;
- technical viability;
- process development time;
- consideration of space requirements;
- possible restrictions imposed by planning legislation;
- health and safety considerations;
- excessive costs;
- other practical considerations such as fuel consumption, yield, physical space and other site specific factors; and
- 'availability' of particular techniques.

The RCEP suggested that the screening of options should pay particular account to low pollution technology, recycling rather than disposal and cross-media pollution transfers. It may be appropriate for the Agency to highlight these issues in its list of factors. The former issues may be considered to be of as much interest during the derivation of BATNEEC as IPC BPEO and may therefore be considered to be already adequately addressed by the IPC system. However, the latter, cross-media considerations, is at the crux of the use of IPC BPEO and it may be particularly beneficial to highlight this amongst the screening factors as a means of encouraging process operators to look for the total, potentially unexpected, environmental impact of their operations.

Recommendation 28: The Agency should consider expanding its list of option screening criteria, particularly relating to the cross-media implications of options.

Shell made use of a one page proforma to record comments for each option when assessed against the screening criteria. The Agency may consider it appropriate to develop a similar proforma for use in its guidance. This would promote the maintenance of an audit trail during the element of the overall assessment procedure that is perhaps most susceptible to loss of transparency in the decision making process.

It may also be appropriate for the Agency to consider whether the development of such a screening proforma could be done on the basis of sector by sector approach, recognising that certain sectors may have their own particular screening criteria against which options can be assessed.

Recommendation 29: The Agency should consider developing a proforma by which the audit trail for option screening could be improved.

Environmental management systems (EMS) may offer an opportunity for improving the generation and screening of options. Firstly by encouraging organizations to be more proactive in identifying options very early in the decision making process (there is a danger that options are dismissed because they are not well known to the operator and hence little information has been collected on them that can be used in what may have to be a rapid screening process). In a similar vein it may enable organizations to be more proactive in collecting data on local environmental conditions, against which the harm caused by various options can be assessed, however, coarsely, during the screening process. Secondly by improving the audit trail when decisions are made. Lastly by ensuring that organizations exhibit greater consistency in their decision making procedure, i.e. over time and between sites.

Recommendation 30: The Agency should consider whether the use of EMS by process operators can be used to improve the present approach to option generation and screening.

3.6.2 Identification of the best and best practicable options

Another important factor when considering options, is the mechanism for the identification of the one that is 'best' or 'best practicable'. The concepts of "best" and "best practicable" are implicit in most applications of the methodologies considered in this study, aside from the ones that specifically set out to identify the BPEO. There are therefore few comparisons or specific guidance on criteria that can be used to assist Inspectors in making judgements associated with these terms.

Criteria for best

The Royal Commission's guidance is obviously relevant. In their 12th report they state in relation to "best" that

> "It is doubtful if there is ever an absolute best. The option chosen as best will depend on the interpretation and evaluation of the predicted impacts by whoever takes the final decision. It is unlikely to be the best choice for all time ... A BPEO must therefore be kept under review".

In terms of the present Agency procedures this advice is followed by current guidance and by the review process included in the authorisation procedure.

The current Agency guidance in relation to IPC authorisations makes use of "best" twice. In BATNEEC, where "best" is defined as "most effective in preventing, minimising or rendering harmless polluting releases" and one in IPC BPEO. There is, however, no separate definition of the "best" in IPC BPEO. The complete definition of IPC BPEO is:

> "The option which in the context of releases from a prescribed process, provides the most benefit or the least damage to the environment as a whole, at a cost that is not excessive, in the long term as well as the short term".

There is a slight difference of emphasis here in that this definition includes the concept of "most benefit to the environment as a whole" which is not included in the definition of BATNEEC. This difference may be significant in that the release of some substances to the environment can give rise to "benefits", e.g. sulphur released to the air can compensate for soil deficiencies and hinder fungal diseases of plants. Currently such benefits are not recognised in the guidance offered for IPC BPEO assessment.

The inclusion of the "benefits" phrase seems to originate in the RCEP definition of BPEO. In taking the RCEP definition and refining it to fit the needs of IPC, by including the phrase " in the context of releases", the Agency may have overlooked the new implication that releases could have benefits. RCEP in deriving their definition were, of course, not constrained to considering impacts resulting from releases and so would legitimately have imagined impacts from other activities whose benefits may be more obvious. The Agency should give urgent consideration to the inclusion of "most benefit" in their definition of IPC BPEO. It may be that the best solution would be to bring the IPC BPEO definition more in line with the "best" of BATNEEC and exclude benefits from the definition.

Recommendation 31: The Agency should re-consider the inclusion of "benefit ...to the environment" in their definition of IPC BPEO and if it is to be retained to consider what guidance it should give on the approach to the assessment of benefits arising from the release of substances.

Criteria for best practicable

The "practicable" part of the IPC BPEO definition is logically the part that states "at a cost that is not excessive" and this part parallels the "available" and "NEEC" parts of BATNEEC. Arguably these are not quite the same, for example, equipment may be "available" and its use may be considered NEEC by the Inspectors yet operators may consider the costs excessive. However, this is probably not of major importance.

The RCEP in considering "practicable" followed similar lines to those used by HMIP in the term "best practicable means". The RCEP stated that:

> "the use of the term practicable implies that the option must be in accordance with current technical knowledge and must not have disproportionate financial implications".

The financial implications involved were considered to extend to those met from the public purse but how far this was intended to extend into environmental externalities is not clear. The RCEP report sought to exclude socio-political considerations from the BPEO considerations. While this may be desirable technically, in view of the Brent Spar incident and other developments, it seems fairly clear that wider considerations will in practice play an increasing role in the identification of BPEO. In IPC, however, the wider socio-political considerations are probably best left to the appeal procedure. The IPC BPEO considerations of best practicable are therefore very much in line with RCEP views in concentrating on not excessive costs and technical availability.

The other methodologies considered in this study do not provide many useful insights into how "best practicable" decisions may be made. The application of EIA in support of planning decisions implicitly involves a social acceptability assessment by virtue of the necessary consultation phase. In a similar vein the current guidance on ERA in the USA advocates a wide involvement of different parties at an early stage in analysis which implies a similar goal of deriving a socially acceptable best option.

It seems therefore that other methodologies give more weight, implicitly, to social acceptability than IPC BPEO which bases its criteria more on cost considerations and availability. In this respect IPC BPEO is in line with RCEP recommendations which specifically emphasised these aspects and differentiated between BPEO and socio-political considerations. However, as shown by the Brent Spar incident, in practice, it is often not possible to maintain such a clear distinction. The Agency has to make decisions that have social and political implications, this is a fact of life, but it seems sensible at present to treat IPC BPEO as a technical assessment with criteria based on cost and availability and to leave socio-political aspects to the appeal procedure. This is the line currently being followed and is consistent with the RCEP viewpoint.

A further point of concern raised by Inspectors during the study but not one that emerged clearly from the case studies was that concerned with the final stage of identification of IPC BPEO; that of deciding from a range of different indices, including cost, which represented the "best practicable". This is, of course, a classic problem in public policy areas and to some extent is inevitably "political". The case studies and other methodologies do, however, provide some guidance that may be of general use. The first relates to the scaling chosen in the indices for the different impacts considered in the assessment process. There is a natural tendency to assume that a measure with a value of 1000 is more significant than one with a value of 1. However, the values provided in the methodology vary widely in their magnitude. Either the values should be scaled to represent the measure of their environmental significance, which would be quite difficult to do in a general way, or alternatively they should be scaled to a similar range, say 0 to 1. This latter approach is often done in application of impacts for EMSs. An alternative approach also used in the application of EMS is to relate the releases from the site concerned to those of the region or nation as a whole in order to put the site values into perspective.

There are approaches to decision making given a range of non-comparable criteria, for example, multi-attribute analysis and economic approaches like contingent valuation analysis can be applied. However, such techniques require extensive data inputs and would be difficult to treat in a general way to guide Inspectors' decisions and are not recommended at this stage in their development. Nevertheless, it does seem that some guidance is required. It may be that some simple guidance on visual presentation such as histogram presentation would help particularly if linked to the kind of scaling to national scale identified above.

Recommendation 32: Guidance is needed to Inspectors and others on the way to reach decisions in the face of differing values for different environmental and economic effects.

4. CONCLUSIONS AND KEY RECOMMENDATIONS

This section draws upon the findings of the reviews of other environmental assessment methodologies (Section 2) and the case studies (Section 3) to identify the main conclusions and recommendations arising from the study.

4.1 Case Studies

At the time of this study it appeared that only two BPEO assessments had actually been undertaken using approaches other than that developed by HMIP/Agency (NWW 1994, Shell 1994).

To address this lack of practical examples of BPEO assessments, use was made in this study of a number of case study IPC BPEOs that the Agency had previously commissioned. Unfortunately the use of the Case Studies to inform on the Agency's methodology was severely constrained as they were based on hypothetical control, rather than process, options for existing processes for which no variations were actually planned. A recommendation is made that it may benefit the Agency to critically appraise an IPC BPEO assessment for a new process, preferably one involving the consideration of real process options.

Despite these limitations, some useful conclusions can be drawn from the consideration of the case studies. Five main issues were identified and these may be broadly summarised as:

1. The specific aims and objectives of IPC BPEO.

2. The types of effect covered.

3. The availability of data upon which to base an assessment.

4. The format of guidance on the IPC BPEO Methodology.

5. Option generation and screening.

4.1.1 Aims and objectives

There appears to be confusion about the relationship of the Agency's IPC BPEO Methodology with other approaches to BPEO, such as those adopted by the RCEP and Shell. IPC BPEO is legally constrained as to the environmental effects that it can assess to a much greater extent than the other two approaches, yet it is to the latter approaches that the public and probably much of industry look for their understanding of the concept. A recommendation is made to the effect that the Agency should consider clearly differentiating its approach from those of other parties by always prefixing its Methodology with a term such as 'IPC BPEO'.

In fact the confusion surrounding the differences between the generic (RCEP/Shell) connotations of the term and the Agency's methodology may well be exacerbated by the Agency's new sustainability duty. The sustainability duty may be perceived as requiring the IPC

BPEO Methodology to mirror rather more the approaches of others which have the potential to consider a far wider range of effects. A further recommendation is made to clarify the relationship between IPC BPEO and the Agency's sustainability duty.

4.1.2 Effects covered by the methodology

The EPA 90 constrains the Agency's BPEO methodology to a consideration of releases from prescribed processes. However, the Methodology does not provide guidance on how a number of major types of release (for example, associated with sensitive receptors, unplanned but foreseeable releases, energy, sewage sludge and ozone depletion) should be assessed. It was noted from the case studies that in the absence of guidance, it was highly unlikely that the effects associated with such releases would be assessed. Recommendations are made to address this lack of guidance.

4.1.3 Availability of data for effects assessment

Problems arose in all of the case studies due to the lack of suitable data upon which an assessment could be based. These deficiencies included lack of data on ambient concentrations and the lack of suitable comparator values against which harm could be assessed. Recommendations are made to address these problems.

4.1.4 Guidance

The Agency has already issued extensive guidance on its IPC BPEO Methodology but it is apparent from the case studies that it may merit further refinement to aid the user, for example the development of an electronic version. Benefits may also be accrued from a better integration of the IPC BPEO guidance with that produced by the Agency in IPC Guidance Notes. Recommendations are made on these lines.

4.1.5 Option generation, screening and assessment

Option generation, screening and assessment is perhaps the key element of the IPC BPEO Methodology. Unless it is done diligently and transparently many of the potential benefits that may arise from the use of this Methodology can be lost. It is recommended that the Agency should consider developing a proforma, possibly on a sector specific basis, upon which process operators can record each option considered and the reasons why those disposed of during the initial screening have not been taken forward for more detailed consideration.

It is also recommended that the Agency consider its present definition of IPC BPEO to ensure that the use of "benefit ...to the environment" does not mitigate against the identification of the IPC BPEO.

Finally, a recommendation is made to the effect that the Agency should improve the guidance it provides to Inspectors on how to assess the relative importance of different types of environmental effect.

4.2 Other Assessment Methodologies

The other element of this project was to consider whether the concepts, practices and tools of other environmental assessment and management techniques could augment and complement the IPC BPEO approach. The techniques considered are described in outline in Section 2 and in greater detail in Appendix A.

It was clear from a consideration of these other assessment techniques that none offer a 'panacea' for the problems that industry complain of with regard to the Agency's IPC BPEO Methodology. A few areas have been identified that may specifically benefit the Agency's Methodology but in general it is apparent that the other assessment techniques are as likely, if not more so, to look to the Agency's approach for solutions to their own problems.

Life cycle assessment (LCA) may be of particular use if the IPPC Directive requires a greater consideration of energy use during an IPC BPEO assessment, in particular by the use of the life cycle inventory (LCI) stage of the methodology. An International Standard for LCA is currently under development and this may lead to the introduction of formalised guidance on the normalisation and weighting of different environmental effects.

Environmental impact assessment (EIA) may inform the Agency on the assessment of the release of odours and noise but this should be viewed in the context of the lack of a uniformly accepted approach to these types of assessment. There is considerable commonality between EIA and IPC BPEO in terms of their use to support regulatory systems. The Agency may therefore find it of use to consider how its approach to assessing releases could be utilised in EIA. This would have the benefit of ensuring a greater consistency in the decision making processes of the two regulatory frameworks, as well as potentially reducing the administrative burden on industry.

Environmental management systems (EMS) are not in themselves assessment methodologies but they may provide a framework in which the preparation of IPC BPEOs can be improved. In particular by encouraging a more proactive and transparent approach to option generation and screening.

Eco-control can be viewed as an attempt to amalgamate LCA and EMS. In this sense it has both the strengths and weaknesses of the two approaches and cannot be considered to provide any unique aspects that may be used to improve IPC BPEO.

The RCEP proposed the original concept of BPEO and its work has shaped to a considerable extent the subsequent development of a BPEO methodology by HMIP (The Agency). The RCEP provided a high level outline of the principles of BPEO assessment but did not provide any examples of how, for instance, harm and significance should be assessed. The IPC BPEO Methodology follows the RCEP's outline and in this sense the RCEP cannot inform to any great extent the further development of the Agency's current approach.

Environmental risk assessment (ERA) may offer longer term ideas on the further integration of risk into the IPC BPEO Methodology but for now its broad nature does not provide scope for specific recommendations.

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APPENDIX A SUMMARIES OF OTHER ASSESSMENT METHODOLOGIES

A1 LIFE-CYCLE ASSESSMENT (LCA)

Life-Cycle Assessment (LCA) is an evolving environmental management technique which compiles and evaluates the inputs and outputs and the potential environmental impacts throughout the life-cycle of a product, process or activity. The majority of published LCAs have involved the comparison of product flows within systems; in particular beverage containers and various packaging options.

Few attempts have been made to apply this technique to an assessment of process options. Recent work (MacLanaghan 1996) has used LCA to compare the relative environmental burdens of disposing of sewage sludge by incineration and short rotation coppicing (the application of sludge to rapid growth plantations, the trees for which can be used as fuel in power generation).

Although, the work has broken new ground in terms of comparing process options, it was only able to assess global environmental impacts, e.g. relative contributions to global warming, long range acidification etc. As yet the technique cannot be applied on a site specific basis. Therefore issues such as the use of pesticides can only be assessed in terms of the energy requirements required to manufacture, transport and apply them. The more significant environmental impact of pesticide use, their potential impact on water resources, cannot be assessed because this is a site specific consideration. Similarly, actual releases of heavy metals from incineration and sludge application cannot be linked to a relative level of harm at a specific site.

LCA may therefore be of greater assistance to the Agency in informing decision making on the selection of BATNEEC, where various process and control options can be compared for their relative use of energy, rather than IPC BPEO which requires a site specific consideration of environmental impact.

A1.1 Application

LCA can be applied in three main ways:

- internally - inform as to the environmental performance of one product versus a competing product which provides the same function;
- externally - to assist in strategic policy development, e.g. the development of waste management strategies;
- identification of areas for optimisation, e.g. leading to a reduction in energy and material intensity.

A1.2 Regulation

No regulatory requirements exist for LCA per se. However, there is a developing body of standards for LCA under the auspices of the International Standards Organization (ISO) and specifically ISO/TC207/SC5 'Environmental Management'; development is assisted and monitored by the British Standards Institute (BSI). The following standards are planned:

- ISO 14040 - Life-Cycle Assessment - Principles and Guidelines
- ISO 14041 - Life-Cycle Assessment - Life-Cycle Inventory Analysis
- ISO 14042 - Life-Cycle Assessment - Impact Assessment
- ISO 14043 - Life-Cycle Assessment - Interpretation

ISO 14040 is the most advanced; the decision was recently taken to raise 14040.3 to a Draft International Standard. The Society of Environmental Toxicology and Chemistry (SETAC) is the foremost body involved in the development of a methodological framework for LCA.

LCA is also finding its way into legislation and guidance as an 'enabling mechanism', for example in providing a scientific and transparent basis for criteria setting in the EU Eco Label Award Scheme (Council Regulation 880/92) (CEC 1992).

A1.3 Scope

The scope of LCA extends to:

- product related - including those covered by the EU's Eco-Label Award Scheme;
- process related, e.g. sludge management options;
- activity related.

The vast majority of LCAs have been applied in the former context.

A1.4 Assessment Boundaries

Within an LCA study, it is necessary to define a number of boundary setting elements in a transparent manner; these include the stated goal(s) of the study, assumptions made, positioning of the cradle and grave, data limitations and the setting of the functional unit.

There are no statutory constraints on where the boundaries for an LCA need be set and in this sense it is an extremely flexible assessment technique. The boundaries can be set to mirror the requirements of the organization commissioning the LCA and need not be constrained to the limits of that organization's control over the environmental impact of the activity/process/product of interest.

Thus for a specific product, an LCA may cover the activities of the many different bodies involved in the product's life cycle, for example those that locate, obtain, transport and treat raw materials and energy for the product; those that fabricate the product; those that distribute and market it; and those that collect the waste associated with all stages.

A1.4.1 System Boundary, cradle and grave

The system boundary separates the product, process or activity from its surroundings - the system environment. In the most holistic 'cradle to grave' context, the system environment is the source of all inputs to the system and the sink for all outputs from the system.

A1.4.2 Temporal and Spatial Boundaries

The Life-Cycle Inventory (LCI) approach is the most holistic of the available environmental management techniques, in terms of its quantitative description of a product, process or activity. Upstream and downstream operations over the 'whole-life' are accounted for. All data throughout the life-cycle is aggregated in the LCI in a mass and energy balance framework; this results in the loss of its temporal and spatial components. The systematic approached adopted by LCI may be of value in IPC BPEO.

A1.4.3 Environmental Impact Boundaries

The SETAC problem-orientated approach is the most widely applied to impact assessment within LCA; it assesses the potential global effects of the environmental burdens identified in the aggregated LCI. No temporal or spatial desegregation of impacts from the global to the regional or national level is made. As mentioned earlier, LCA is not presently capable of assessing site specific environmental effects.

A1.4.4 Functional Unit

The Functional Unit defines the measure of performance that the system delivers. For example, total energy use by various process options may be compared in terms of energy use per unit of production. More detailed analysis can be undertaken in the same manner for the various elements that make up a process option to identify those that are the greatest utilisers of energy.

A1.5 Impacts considered

In the problem orientated approach the following potential global environmental effects are typically included:

- greenhouse effect;
- ozone layer depletion;
- acidification;
- nutrification;

- photochemical oxidant formation;
- human toxicity;
- aquatic ecotoxicity.

These global impacts tend to be assessed in a similar manner to that adopted in the IPC BPEO Methodology, i.e. by using global warming potentials (GWPs), photo-chemical ozone creation potential (POCP) etc.

In the final 'valuation' component of life-cycle impact assessment, these effect categories can be ranked by assigning weighting factors. However, the valuation of one potential global effect relative to another is very subjective and surrounded by controversy. In this sense LCA can be said to share the same problems as IPC BPEO rather than provide it with a solution.

A1.6 Prescriptiveness

Within the context of their being no legislative requirements for LCA, the prescriptiveness for conducting a Life-Cycle Inventory - using a synthesis of the available guidance and literature is moderate to high, i.e. there is a fairly uniform approach amongst practitioners to undertaking this part of the assessment.

On account of the assessment of potential global impacts, and the subjective nature of the 'valuation' component, the prescriptiveness of Life-Cycle Impact Assessment is low, i.e. there is little or no uniformity of approach.

A1.7 Terminology

A number of important definitions relate to LCA, including:

- **system boundary** - interface between a product system and the surrounding environment;
- **cradle to grave** - holistic end-points for the study;
- **mass and energy balance** - method used in the Life-Cycle Inventory to quantify the inputs and outputs associated with the raw material and energy flows utilised.

A1.8 Methodology

Following the SETAC framework, LCA comprises of four main stages:

1. **Goal Definition and Scope**: explicitly defines the goal(s) and boundaries of the study.
2. **Life-Cycle Inventory** (LCI): structured approach to data collection, representing the most holistic environmental management technique available. All inputs (flows of materials and energy) and subsequent releases to each environmental compartment are quantitatively described.

3. **Life-Cycle Impact Assessment**: the 'problem-orientated' approach seeks to assess the potential global environmental impacts arising from the aggregated inventory, comprising three main components:

   - **classification**: the elements of the inventory are assigned to impact categories, e.g. CO_2 releases to global warming;

   - **characterisation**: the ranking of releases within impact categories, for example the relative contributions to global warming of methane and carbon dioxide using their global warming potentials;

   - **valuation and/or normalisation:** valuation attempts to rank across impact categories, e.g. global warming relative to eutrophication. Normalisation relates the total release within an impact category to national or global releases over a defined timescale, e.g. per annum. As with other assessment techniques this has perhaps proved to be the most difficult element of LCA with no clear policy having developed on how it should be addressed. The International Standards Organization is currently undertaking work in this area, but progress is slow and it is likely to be some time before it publishes any conclusions.

4. **Life-Cycle Improvement Assessment**: the use of sensitivity analysis enables the changes which most affect the overall inventory and hence impact to be identified, highlighting the most promising areas for improvements. However, there is ongoing debate from within the LCA community as to whether this is a component part, or an application of LCA.

A2 ENVIRONMENTAL MANAGEMENT SYSTEMS

An Environmental Management System (EMS) is a structured approach to the management of environmental matters within an organisation. The British Standard BS7750 (BSI 1992) provided the first standardised model of an EMS, and has been followed by numerous other national standards of similar type, and there is now an International Standard ISO/DIS14001.

The EU's Eco-Management and Audit Scheme (EMAS) has absorbed many BS7750 concepts, and differs mainly from the above-mentioned EMS standards in requiring participants to provide a publicly-available and independently verified statement of corporate environmental performance.

A2.1 Application

An EMS is potentially applicable by any organisation, large or small, public or private, industrial/commercial or not-for-profit. BS7750 and ISO/DIS14001 have been developed with such a broad range of organisations in mind. EMAS has been designed specifically for industries in the more potentially polluting sectors, and covers manufacturing, electricity, gas, steam and hot water production, and the recycling, treatment destruction or disposal of waste. It may, however, be extended on a trial basis to other sectors at the discretion of EU Member States; thus, for example, it has been so extended in the UK to the Local Government sector.

A2.2 Regulation

All the above EMS initiatives are voluntary, although EMAS was introduced by an EU Regulation - obliging Member States to establish the infrastructure to support the voluntary scheme (CEC 1993).

A2.3 Scope

BS7750 and ISO/DIS14001 are both applicable to organisations or to sites, whereas EMAS is applicable to sites. As holistic approaches to environmental management, none are specifically designed to apply to individual processes (although ISO/DIS14001 refers to its application to an "activity").

A2.4 Assessment boundary

There are no prescribed spatial or temporal boundaries for evaluating environmental effects (BS7750, EMAS) or impacts (ISO/DIS14001).

Indeed, all the above EMS models require that the following be addressed, although there are differences of detail and emphasis:

- Direct and indirect effects;
- Past, current and planned activities, products and services; and
- Normal, abnormal and emergency situations.

In general, the degree of prescriptiveness and detail of the three models (in this and other areas) is:

EMAS ~ BS7750 > ISO/DIS14001

with ISO/DIS14001 placing in its Guidance section much material which EMAS and BS7750 specify as requirements.

BS7750 requires the evaluation of effects/impacts which the organisation can control or - to address the issue of indirect effects - be reasonably expected to influence, as a precursor to setting environmental objectives. EMAS is similar, but does not contain the reference to expectation of influence.

ISO/DIS14001 requires identification of "environmental aspects" of activities, products and services which the organisation can control, or be expected to influence, and that those aspects giving rise to significant impacts be considered in setting objectives.

With respect to indirect effects arising from purchasing, from contracting, and from product use and disposal:

- BS7750 requires the environmental probity of suppliers to be considered. It recognises, however, that a detailed register of suppliers will not always be possible and refers to the possibility of comparing alternative suppliers in respect of their most important environmental effects.
- None of the models requires detailed Life Cycle Assessment (LCA) of products/services.
- All of the models refer to contractors.

EMAS makes specific reference to providing customers with advice on environmental aspects of product handling, use and disposal.

A2.5 Impacts considered

Basically, all three EMS models refer (with varying wording) to the consideration of:

- Emissions to atmosphere.
- Discharges to water.
- Wastes.

- Contamination of land.
- Use of raw materials and natural resources.
- Noise, odour, dust, vibration and visual impact.

ISO/DIS14001 contains this list in the Guidance section. whereas BS7750 and EMAS include it as part of their requirements. EMAS and BS7750 also refer to "effects on specific parts of the environment, including ecosystems", but ISO/DIS14001 does not. EMS thus potentially requires the consideration of a greater range of effects than does IPC BPEO.

A2.6 Prescriptiveness

None of the models describes or prescribes the methodology for evaluating the "significance" of environmental effects/impacts. In practice it is likely that those implementing EMS will actually turn to sources such as IPC BPEO to seek guidance on how the assessment of 'significance' and 'harm' should be undertaken.

A2.7 Terminology

All three models introduce definitions of terms which they use in a specialised way - including variously, for example: environment, environmental effect, environmental aspect, environmental impact, environmental performance. There has been considerable debate as to whether the term 'environmental effect' used in BS7750 and ISO/DIS 14001 is truly analogous to 'environmental impact' used in ISO/DIS 14001. The suggestion being that a consideration of 'impacts' could be considered to be less demanding than a consideration of 'effect'.

A2.8 Methodology

As noted above, none of the EMS models provides a detailed approach to evaluating environmental effects/impacts. There are references in some of them to consideration of the views of interested parties, to scientific and technical knowledge about the effects and to risk assessment, but no detailed methodology is offered. This reflects, in part at least, the fact that they are high-level models for environmental management in a very wide range of organisations.

BS7750 Sector Application Guides (SAGs) have been developed for over a dozen sectors, although their scope and depth vary widely (Electricity Association 1994). Some contain more detailed guidance on the conduct of effects evaluation, but the degree of detail varies widely and none gives the comprehensive guidance that is given in the IPC BPEO Methodology. Typically, a SAG will give information on likely significant effects within a sector, which implementing organisations should consider, and may also provide very basic advice on simple systems for prioritising routine effects and for assessing the risks associated with emergency conditions. SAGs may therefore be of some use if the Agency decides to take a more sector specific approach to the way it provides guidance on IPC BPEO.

Further information on effects evaluation is also given in EMS texts, probably in greatest detail in Hunt and Johnson (1995). Such advice includes:

- Recognising the subjective nature of the process, inasmuch as comparative evaluation of widely differing types of effects is fundamentally impossible, and suggesting the use of a group approach to, for example, weighting different effects to avoid individual biases.

- Using hierarchical checklists, in combination with a structured approach to considering activities, products and services, to try to ensure that all potentially significant effects are considered. (The structured approaches include an LCA-type matrix of Effects/Impacts versus Life Cycle Stage - Raw Material, Production, Distribution, Use, Disposal/Recycling - and a simpler Activities/Effects matrix).

- Avoidance of seeking and using inappropriately detailed quantification of effects.

- Use of HAZOP/HAZAN/FMEA and other, simple risk-based approaches to address potential effects from emergencies.

- Use of Ratios (e.g. to national or sectoral data), suitably normalised (e.g. employees/total employed, turnover/GDP) to help assess the significance of resource use and of contributions to regional/global effects. (Suggested guide to interpretation of Ratios: >10, almost certainly significant; 10-1, probably significant; 1-0.1, probably not significant; <0.1 almost certainly insignificant; but need to consider absolute magnitude of consumption/ production also emphasised.)

- The possible use, outside IPC, of the IPC BPEO assessment approach developed by HMIP, or parts thereof. (Attention is also drawn to the problems in that approach in simultaneously evaluating the different indices and scores, and to the possible use of a Delphi approach - as adopted in one LCA study - to derive weighting factors).

Finally, it should be noted that ISO TC207, Environmental Management, which is the parent of a number of Sub-Committees dealing with EMS, Auditing, LCA etc has a Sub-Committee SC4 addressing Environmental Performance Evaluation (EPE). The work of this group will have considerable relevance to EMS implementors in their approach to effects/impacts evaluation and objective-setting, but it is understood that progress has been relatively slow, draft documents are not yet in the public domain and publication of an International Standard giving guidance on EPE is not imminent. It appears that SC4, in developing its generic guidance on EPE, originally divided evaluation areas into Operational, Management and Environment categories, the first two of these being considered under the direct control of the organisation. However, this distinction has not been made in the latest draft and further developments are awaited.

A3 ENVIRONMENTAL IMPACT ASSESSMENT

For certain planned developments an environmental impact assessment (EIA) must be prepared by the developer and submitted to the planning authority as a part of the planning application process. EIAs are intended to provide the planning authorities, and any statutory consultees to the planning process, with a systematic review of the potential environmental effects that may arise as a result of a development taking place (National Power 1994, WBSCD 1996).

A3.1 Application

Environmental impact assessment is applied during the planning of certain new activities.

A3.2 Regulation

The Town and Country (Assessment of Environmental Effects) Regulations 1988 (SI 1199) (HMSO 1988a) implement in the UK the provisions of the EC Directive on the assessment of the effects of certain public and private projects on the environment (CEC 1985). Statutory Instrument 1199/1988 covers most aspects of the Directive. However, certain types of development are covered by specific Regulations and these are summarised below:

- the Highways (Assessment of Environmental Effects) Regulations 1988 (SI 1241) (HMSO 1988b).
- Electricity and Pipe-line Works (Assessment of Environmental Effects) Regulations 1989 (SI 167) (HMSO 1988c).
- The Environmental Assessment (Afforestation) Regulations 1988 (SI 1207) (HMSO 1988d).
- Land Drainage Improvement Works (Assessment of Environmental Effects) Regulations 1988 (SI 1217) (HMSO 1988e).
- Harbour Works (Assessment of Environmental Effects) Regulations 1988 (SI 1336) (HMSO 1988f).
- The Environmental Assessment (Salmon Farming in Marine Waters) Regulations 1988 (SI 1218) (HMSO 1988g).

Note: The EU's Council of Environment Ministers has recently agreed the text of a proposed Directive to amend and update the 1985 Directive.

A considerable amount of guidance has been issued on the implementation of Regulations relating to EIA (Environment Agency 1996b, HMSO 1990, HMSO 1991, HMSO 1994) but this guidance has tended to concentrate on administrative considerations rather than providing detailed guidance on how to assess 'harm'. The Institute of Environmental Assessment has also issued more detailed guidance on how to undertake EIAs. This guidance, although not statutory, is quite widely used, and may inform the Agency on the assessment of issues such as

noise and odour releases. However, it cannot inform on the more complex issue of assessing the release of hazardous substances and as with EMS and LCA, EIA practitioners may well look to the Agency's IPC BPEO Methodology for guidance in this area.

A3.3 Scope

The Directive, and subsequent implementing UK legislation, contains two lists of developments for which an environmental impact assessment may have to be undertaken.

An EIA is mandatory for developments on Schedule 1, but need only be undertaken for developments on Schedule 2 when it is believed that the development may give rise to 'significant' environmental effects. Little guidance has been provided on how 'significance' should be assessed and thus the need for discretionary EIAs identified. Guidance (Circular 15/88) issued by the Department of the Environment (DoE 1988) suggests that the three main criteria of significance are:

1. whether the project is of more than local importance, principally in terms of physical scale.

2. whether the project is intended for a particularly sensitive location, for example, a national park or a site of special scientific interest (SSSI), and for that reason may have significant effects on the area's environment even though the project is not on a major scale.

3. whether the project is thought likely to give rise to particularly complex or adverse effects, for example, in terms of the discharge of pollutants.

The Circular also provides some indicative thresholds which may be used to identify the need for EIAs relating to specific developments. Despite the issuing of the Guidance there is still considerable confusion relating to when a discretionary EIA should be undertaken. One of the primary reasons for the recent publication of a proposed Directive to amend the EIA Directive (85/337/EEC) is to clarify when discretionary EIAs should be used.

Some examples drawn from the Guidance are provided below.

(a) Agriculture

New pig rearing installations for more than 400 sows or 5000 fattened pigs may require an EIA.

(b) Extractive industry

Opencast coal mines and sand and gravel workings of more than 50 hectares may require an EIA.

(c) Manufacturing industry

New manufacturing sites in the range of 20-30 hectares may well require an EIA.

(d) **Industrial estate developments**

Industrial estate developments may require an EIA where the site of the estate is greater than 20 hectares or there are a significant numbers of dwellings in close proximity to the site of the proposed estate, e.g. more than 1000 dwellings within 200 metres of the site boundary.

(e) **Waste disposal**

Installations, including landfill sites, for the transfer, treatment or disposal of household, industrial and commercial wastes with a capacity of more than 75 000 tonnes a year may well require an EIA.

A3.4 Assessment boundaries

Environmental impact assessments are undertaken at the planning stage, i.e. prior to the commencement of development. The types of development covered include infrastructure, manufacturing processes and agriculture. No spatial boundaries are defined, although it may be expected that these will invariably be local and site specific.

A3.5 Impacts considered

An environmental impact assessment requires a consideration of possible impacts on the following targets:

- human beings;
- flora and fauna;
- soil;
- water;
- air;
- climate;
- the landscape;
- the interaction between any of the foregoing;
- material assets;
- the cultural heritage.

The Guidance is based on assessing the 'impact' of the site on the defined targets. Unlike IPC BPEO it does not require the assessment to be confined to releases.

A3.6 Prescriptiveness

In general terms the requirements of EIA are moderately prescriptive. However, they must support the planning system, itself a relatively prescriptive system, and concerns have been voiced that guidance relating to the application of EIAs is too vague to allow its effective application.

A3.7 Terminology

The Directive defines the following terms:

project	the execution of construction works or of other installations or schemes: or other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources.
developer	the applicant for authorisation for a private project or the public authority which initiates a project.
development consent	the decision of the competent authority or authorities which entitles the developer to proceed with the project.

A3.8 Methodology

EIA legislation and associated guidance outlines an administrative procedure to be followed by both developers and planning authorities when considering the environmental aspects of a planning application. It also provides some guidance on the type of information that should be provided in an EIA.

The crux of an environmental impact assessment is the preparation of an Environmental Statement. An Environmental Statement comprises a document or series of documents providing for the purpose of assessing the likely impact upon the environment of the development proposed to be carried out.

Information should be provided on:

- a description of the development proposed, comprising information about the site and the design and size or scale of the development;
- the data necessary to identify and assess the main effects which that development is likely to have on the environment;
- a description of the likely significant effects, direct and indirect, on the environment of the development, explained by reference to its possible impact on: human beings, flora and fauna, soil, water, air, climate, the landscape, material assets and the cultural heritage;

- where significant adverse effects are identified with respect to any of the foregoing, a description of the measures envisaged in order to avoid, reduce or remedy those effects; and

- a summary in non-technical language of the information provided.

An environmental statement may include, by way of explanation or amplification of any specified information on any of the following matters:

- the physical characteristics of the proposed development, and the land-use requirements during the construction and operational phases;

- the main characteristics of the production processes proposed, including the nature and quantity of the materials used;

- the estimated type and quantity of expected residues and emissions (including pollutants of water, air, or soil, vibration, light, heat and radiation) resulting from the proposed development when in operation;

- (in outline) the main alternatives (if any) studied by the applicant, appellant or authority and an indication of the main reasons for choosing the development proposed taking into account the environmental effects;

- the likely significant direct and indirect effects on the environment of the development proposed which may result from the use of natural resources and the emission of pollutants, creation of nuisances and elimination of waste ('effects' includes secondary, cumulative, short, medium and long term, permanent, temporary, positive and negative effects);

- the forecasting methods used to assess any effects on the environment about which information is given above;

- any difficulties, such as technical deficiencies or lack of know how, encountered in compiling any specific information.

A4 ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION'S (RCEP) 12TH REPORT ON THE BEST PRACTICABLE ENVIRONMENTAL OPTION

The concept of BPEO was first introduced in 1976 in the Royal Commission on Environmental Pollution's (RCEP) fifth report concerned with air pollution control. The twelfth report of the RCEP took the concept a stage further by proposing a broad methodology for identifying the best practicable environmental option (BPEO). Chapter 3 of the 12th RCEP report considers how the BPEO procedure can be applied to improve pollution prevention and abatement.

The 12th Report provides little specific advice on how to quantify environmental impacts, but the scope of the evaluation proposed is very wide. For example it indicates that specific account should be taken of the impact of major accidents on the environment and on the effects of the project on the workforce. It also puts a strong emphasis on the need to identify the full range of feasible options arguing quite correctly that if the 'best' option is not in the list, no amount of detailed evaluation will ever reveal it.

A4.1 Application

The 12th RCEP report is particularly concerned with industrial process regulation but its definition of industrial processes is wider than that laid down in the EPA 90. For example, the RCEP suggests applying BPEO to road construction, waste disposal and agriculture.

A4.2 Regulation

There is no Regulatory basis for these recommendations. They were, however, influential in the subsequent establishment of IPC and IPC BPEO under the Environmental Protection Act 1990.

A4.3 Scope

Although concerned with a specific industrial process the description of the procedure recommended is very broad covering fundamental issues of process design and major hazards.

The recommendations also take account of worker safety and the environmental effects of major accidents in the description of the option that constitutes BPEO. The RCEP methodology does not place any restriction on the types of effect and substance that should be covered by an assessment and in that sense it differs fundamentally from the methodology developed by the Agency which is tightly constrained by the EPA 90.

A4.4 Boundaries

The RCEP does not explicitly define boundaries in its BPEO assessment methodology but it does suggest that certain activities associated with industrial pollution control that are not covered by IPC BPEO should be considered, for example the disposal of solid and liquid wastes to land.

A4.5 Impacts considered

The RCEP did not provide a definitive list of environmental effects that it expected to see covered by a BPEO assessment but it is apparent from its 12th report that it envisaged a consideration of more than 'releases' to which IPC BPEO is constrained by the EPA 90. For example, by way of illustration, the RCEP mentions that assessment has already been applied to consider the environmental effects associated with 'the existence of the development, the use of natural resources and the discharge of liquid, gaseous or solid wastes'. Presumably the former example of the 'existence of the site' relates to effects such as land take, visual intrusion etc.

A4.6 Prescription

The proposed procedure is not very prescriptive but does emphasise the need to be imaginative in seeking alternative process and operating options emphasising that procedures like HAZOP can help in the identification of options and consequences.

A4.7 Terminology

The term BPEO emerged from RCEP but there are no other specific terms.

A4.8 Methodology

The following summarises the stages proposed:

1. Define the objective.
2. Generate options.
3. Evaluate the options.
4. Summarise and present the evaluation.
5. Select the preferred option.
6. Review the preferred option.
7. Implement and monitor.

The RCEP recommends that an audit trial is maintained throughout the seven stages

A5 ENVIRONMENTAL RISK ASSESSMENT

The principles of risk assessment appropriate for environmental protection have recently been summarised by DoE (HMSO 1995). This framework can be used as an aid to decision making in a wide variety of environmental situations.

Environmental risk assessment (ERA) is only a framework and can therefore be applied in principle to any problem of whatever magnitude, spatial or temporal. As a framework it offers little that is new to the development of the BPEO methodology for IPC. However, the practice of dividing the overall risk analysis sometimes used in Environmental risk assessment, into risks of sources, risks of exposure and risks of effects, provides a framework that structures thinking in IPC analysis and assessment. Also a risk framework for decision making makes it easier to deal with the relationships between IPC decisions and those relating to major hazards.

A5.1 Application

ERA has been applied in name at least to a wide variety of environmental issues and problems. As indicated above, ERA is only a framework for thinking and decision making and its purpose is to inform decision makers and usually to help in the consequent development of regulations and the allocation of resources.

A5.2 Regulation

No regulations specify that ERA should be undertaken and there is no regulatory guidance in Europe. However, the USEPA has produced guidance on the application of ERA and the EU's New and Existing Chemicals Regulations and other chemical regulations such as the plant protection products marketing Directive (96/12/EC) use the approaches usually adopted in ERA.

A5.3 Scope

The scope of an ERA depends entirely on the intent being considered and the judgement of the people using the technique.

A5.4 Boundaries

The boundaries of an ERA are determined by the scope of the intent being considered and the judgement of the people using the technique.

A5.5 Impacts considered

The impacts considered by an ERA similarly depend on the intent being considered and the judgement of the people using the technique.

A5.6 Prescription

The application of the broad framework allows a great deal of flexibility to the user of the approach for example there is no prescription as to how impacts are to be evaluated. There is a presumption, however, that there will be a comparison of the probability of events with the magnitude of their severity. The fact that there is thus a recognition of effects rather than an absence of effect often implicit in environmental standards used in the IPC BPEO Methodology is relevant.

A5.7 Terminology

A number of terms have developed in association with the application of risk in a variety of areas. The recent report by HMIP summarises many of them. Perhaps most relevant from the perspective of impact assessment is the distinction between risk estimation, risk evaluation and risk assessment.

- risk estimation is the estimation of the magnitude of a given risk
- risk evaluation is the appraisal of the significance of a given measure of risk
- risk assessment is the combination of both the technical estimation with the judgmental evaluation to produce a value on which decisions are made. Often such decisions are termed risk management.

A5.8 Methodology

There is no definitive methodology for environmental risk assessment. The application and procedures appropriate to IPC have recently been published by HMIP.

A6 ECO-CONTROLLING

Eco-Controlling is a management tool based on the concept of material and energy accounting. It is a tool to integrate environmental and economic targets into business development to achieve a high level of eco-efficiency (ENDS 1996).

A6.1 Application

The methodology can be applied to strategic planning, environmental reporting and as element of the EC eco-audit scheme.

A6.2 Regulation

Not covered by regulation.

A6.3 Scope

Can be applied to various functional units.

A6.4 Assessment boundary

The boundaries depend on the objectives. It can be the process, factory or business site, but can also be wider by including the origins of raw material.

A6.5 Impacts considered

The methodology uses material and energy flows as the basis for the assessment.

A6.6 Prescriptiveness

The methodology is not particularly prescriptive.

A6.7 Terminology

The methodology provides a number of important definitions:

- product flow analysis - the in and output of tradable products (material flow analysis): the unit is mass or volume.
- substances flow analysis - chemical-physical composition of the products and energy carriers (oil, gas, coal, emissions).
- energy carrier flow analysis - all used and produced energy carriers (volume or mass).
- energy flow analysis - the energy flow associated with products and substances including waste heat and noise (Joule or kilowatt hour).
- damage production calculation - estimation of the effect.

A6.8 Methodology

The Eco-controlling system consists of six modules.

Module 1 - Assessment of material and energy flows.

Application of input-output values to processes using a book-keeping system as used by accountants. Total sum of inputs must be equal to total sum of outputs. Requires detailed analysis of the physical-chemical composition of the individual inputs and outputs in particular also those released to the environment.

Module 2 - Pollution

In this module an assessment is made of the origins of the pollution, the pollution carrier and the type of pollution. The boundary to be used is important in assessing the origins of the pollution. The wider the boundary the more elaborate the task.

A stepwise approach is recommended:

- depending on the situation pollution carriers can be defined as the total production, the total production of a product group or of a single product, for instance, a unit of 1 tonne production volume of a particular product can be used as the pollution carrier or the unit benefit the product provides (e.g. a certain degree of insulation).

- the identification of the type of pollutants present may initially rely on data already available (e.g. effluent, dust, solid waste, air emissions).

- the sources of pollution can be either a single process, a number of processes (process line) or the total installation. A distinction is made between internal and external sources. It is important to assess initially the internal sources. The external sources can subsequently be added as they tend to be less important to the overall assessment. The external sources can be treated as pre and/or post processes. If the external sources are included the method can be used as life-cycle analysis (or for eco-labelling). This can eventually be used for a cost/benefit analysis.

Module 3 - Assessment

Because of their different impacts on the environment both material and energy flows must be assessed. Two main methods can be used for the assessment:

- pollution performance indicators (SPI)

- pollution weighting models (SGM).

(a) Pollution indicators

Examples of Pollution Indicators include recycling percentage, material intensity, total NO_x emissions; use of fossil fuels, renewable energy, water use.

A comparison between the amount of material used with the products produced permits an assessment of the material intensity. This method is easy to apply and transparent both to the input and output side.

(b) Polluting weighting models

The weighting can only be applied once the material and energy flows have been identified for a particular installation or a pollution carrier. The weighting has the advantage that the assessment is reduced to a single factor, but it is subjective. To produce a weighting is optional whereas an assessment of the flows is essential. The weighting can be carried out in terms of load or volume.

One weighting model which can be used within limitations is the "critical volume" model. This relies on the use of environmental quality standards. The critical volume is a measure of the volume of air or water exposed to the environmental quality standard as a result of a particular emission.

Each of the volumes for the different substances can then be added to obtain the "critical volume".

For example, if the limit value is 0.03 mg/m^3 then the critical volumes are as follows:

Emission	Critical value
0.03 g	1 m^3
3 g	100 m^3
30 g	1000 m^3

This can be calculated for

- critical air volume;
- critical water volume;
- critical landfill volume (as this value is not very relevant the critical eluate volume could also be used).

To date no information has been given as to whether 1 m^3 air = 1 m^3 water.

Module 4 - Eco-efficiency

The correlation between the pollution produced and the value added can be considered eco-efficiency. For the eco product efficiency the pollution production per unit of pollution is calculated. However, it must be realised that certain products which are produced for the satisfaction of a need can never reach the same eco efficiency as an alternative product made for a different need (e.g. car vs bicycle in a town).

Thus the starting point of the ecological-functionality efficiency must be the need to be satisfied. The pollution production must therefore be related to the functional unit. The relative environmentally most friendly product has the highest product and functional efficiency when compared with the other alternatives. Environmental friendliness is therefore a relative assessment. This assessment also needs to consider economic conditions. This economic-ecological assessment can be demonstrated in a two-dimensional model.

- The ecological axis gives the ecological impact using one of the two assessment methods (indicator or weighting).
- The second axis is the economical axis which could show for instance the economic added value.

Thus one could distinguish four positions:

- very green but low economic return
- very black and low economic return
- very black but high economic return
- very green and high economic return (win/win case).

Module 5 - Improvements and Module 6 Control

The ecological efficiency can be improved by either increasing the value added at equal environmental impact or by reducing the environmental impact for the same value added. For the cost analysis a distinction can be made between fixed and variable pollution production. The first is the result of providing the facility to produce the product (e.g. building, machinery), the second is the result of actually producing the product which is related to the amount of product produced. The ecological product efficiency can be improved by either clean production or by end of pipe solutions. The functional efficiency can be increased by substitution of materials (e.g. less insulation material with equal insulation efficiency).

As the environmental impact is relative a comparison needs to be made between products or processes providing the same function. The current activities and their impacts have to be related to the activity with the same function resulting in the lowest environmental impact. The difference is the Eco-action gap.

Benefits

- The method can be used for the evaluation of different strategies (i.e. the impact of a CO_2 tax).
- The method can be used to clearly identify the corporate aims to reduce environmental impacts without losing competitiveness.
- The method can be used to establish the gap between current practice and minimum environmental impact.
- The method allows the identification of the maximum reduction in environmental impact per unit cost invested.
- The method allows a comparison of different approaches, i.e. avoidance, reduction, re-use, land filling of waste.

A7 IPC BPEO

Extensive guidance has been put out to consultation by the Environment Agency to support the use of IPC BPEO, however, to aid the comparative element of this study, a brief summary of the methodology has been provided below using the standard approach adopted for the other assessment methodologies.

A7.1 Application

IPC BPEO is applied in support of the integrated authorisation of certain prescribed processes.

A7.2 Regulation

The Environmental Protection Act 1990 defines the statutory framework in which IPC BPEO is applied.

A7.3 Scope

IPC BPEO is applied only to prescribed processes.

A7.4 Assessment Boundaries

The EPA 90 defines the boundaries for the use of IPC BPEO to the assessment of releases from prescribed processes. IPC BPEO is not intended to be used to assess the environmental effects associated with activities upstream and downstream of the process.

A7.5 Impacts considered

The EPA 90 restricts the use of IPC BPEO to the assessment of the environmental effects associated with releases from the prescribed process, for example hazardous substances and substances with the potential to cause global warming and the generation of ground level ozone.

A7.6 Prescriptiveness

Supporting guidance to the IPC BPEO Methodology suggests that process operators may adopt alternative approaches to that outlined in the Agency's guidance. In this sense it is of low prescriptiveness, however, if, as will usually be the case, the Agency's guidance is followed the approach has a high level of prescriptiveness.

A7.7 Terminology

The IPC BPEO Methodology draws on the EPA 90 for its definition of substance, harm, environment, pollution of the environment, process etc., and where possible uses the terminology and definitions used by RCEP, adapted to meet the boundaries imposed by EPA 90.

A7.8 Methodology

The IPC BPEO methodology follows extremely closely that of the RCEP. The only step suggested by the RCEP but not covered by IPC BPEO is the RCEP's final one - Implementation and Monitoring.

The six basic steps of IPC BPEO are therefore:

- define the objective;
- generate options to meet the objective;
- assess the options;
- summarise and present the assessment;
- identify the Best Practicable Environmental Option;
- Review the Best Practicable Environmental Option.