TECHNICAL SPECIFICATION

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Environmental management — Quantitative environmental information — Guidelines and examples

Management environnemental — Information environnementale quantitative — Lignes directrices et exemples

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 14033 was prepared by Technical Committee ISO/TC 207, *Environmental management*, Subcommittee SC 4, *Environmental performance evaluation*.

Introduction

This Technical Specification provides guidelines for the acquisition and provision of quantitative environmental information to support the use of the International Standards on environmental management produced by ISO/TC 207. The purpose of this Technical Specification is to help break down the complexity of environmental data handling into manageable and understandable elements, in order to assist the process of gathering and processing quantitative environmental information. This Technical Specification is intended for use by people who work with environmental reporting, e.g. engineers and technical staff.

The structure of this Technical Specification and of the guidelines adheres to the general principle of continual improvement and therefore follows an iterative approach. The guidelines are structured in a Plan, Do, Check, Act (PDCA) cycle, (see Figure 1). In this Technical Specification, PDCA is intended to implement and improve the handling of quantitative environmental information.

This Technical Specification addresses the general issues of data quality by providing clear guidelines on how to acquire and provide quantitative environmental information in a structured way. Data quality is an intended and implicit result from the guidelines provided by this Technical Specification, but it is not specifically addressed throughout the text.

The guidelines range from planning, defining and acquiring quantitative data, to performing mathematical processing. They can be used to review the work that results in environmental quantitative information for an application as part of a method or tool, such as life cycle assessment or environmental performance indicators. The guidelines do not include specific methods or tools, but they address how to acquire and provide quantitative data for such applications.

The guidelines are developed with an understanding that many applications of quantitative environmental information are intended for different types of assessments within organizations. The quality of the results of such assessments greatly depends on the underlying quantitative information. Any type of intended application and related assessment is dependent on first identifying the expectations linked to the results generated using the quantitative environmental information, before establishing statistical and numerical design criteria to be used for data collection.

The guidelines are also developed with the understanding that many applications of environmental information are intended for quantitative comparisons, such as levelling and benchmarking, controlling continual improvement (comparing with the previous year), quantitative identification of priority areas, numerical appraisal and comparison of risks, decisions about design, investment or procurement. This Technical Specification supports quantitative comparisons by highlighting aspects of the planning of the acquisition and provision that are particularly relevant to achieving comparable quantitative results.

This Technical Specification provides guidelines for acquiring and providing a broad variety of quantitative environmental information and data. When an organization applies this Technical Specification for various purposes within its environmental management system, or for specific tools, purposes or applications, maximum benefit is gained by following the principles described in Clause 5.

Environmental management — Quantitative environmental information — Guidelines and examples

1 Scope

This Technical Specification supports the application of standards and reports on environmental management. It provides guidelines on how to acquire quantitative environmental information and data and implement methodology. It gives guidelines to organizations on general principles, policy, strategy and activities necessary to obtain quantitative environmental information for internal and/or external purposes. Such purposes can be, for example, to establish inventory routines and support decision making related to environmental policies and strategies, aimed in particular at comparing quantitative environmental information. The information is related to organizations, activities, facilities, technologies or products.

This Technical Specification addresses issues related to defining, collecting, processing, interpreting and presenting quantitative environmental information. It provides guidelines on how to establish accuracy, verifiability and reliability for the intended use. It utilizes proven and well-established approaches for the preparation of information adapted to the specific needs of environmental management. It is applicable to all organizations, regardless of their size, type, location, structure, activities, products, level of development and whether or not they have an environmental management system in place.

This Technical Specification supplements the contents of other International Standards on environmental management.

NOTE Annex A provides illustrative guidelines, examples of how to apply the guidelines and case studies with examples.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14050, *Environmental management — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14050 and the following apply.

3.1
activity data
quantitative measure of an activity that results in an environmental impact

3.2
basic data
data acquired from a data acquisition process

NOTE Basic data consist of one or several values and units, depending on the nature of the item that the basic data represent. Some basic data can be dimensionless and have no units, e.g. an index or ratio.

3.3
data quality
characteristics of data that relate to their ability to satisfy stated requirements

[ISO 14044:2006, definition 3.19]

3.4
data source
origin of information

EXAMPLES Literature; databases; human resources; instruments.

3.5
physical object
identifiable entity in the real world which is described by basic data

EXAMPLES An existing production plant; an output of an emission, effluent or deposit; a potential eco-system.

3.6
system
group or groups of independent and interrelated objects or processes

3.7
transparency
open, comprehensive and understandable presentation of information

[ISO 14044:2006, definition 3.7]

3.8
quantitative data
numerical data item which includes its unit

3.9
quantitative information
quantitative data which has been processed or analysed to be meaningful for a specific purpose or objective

NOTE Quantitative data can originate from primary or secondary data sources. See 6.2.6 for examples of primary and secondary data.

4 Use of quantitative environmental information

4.1 General

Quantitative environmental information is used for environmental measurements, calculations, assessments, comparisons, reporting and communication. This Technical Specification supports any such use or application of quantitative environmental information throughout International Standards on environmental management. Examples are environmental performance indicators, environmental communication, environmental declarations, life cycle assessment, greenhouse gas emission reporting, carbon footprint, water footprint, eco-efficiency, reporting to authorities, sustainability reporting and social responsibility reporting.

The role of an application in relation to this Technical Specification is shown in Figure 1. The requirement of an application is the basis for the specifications for how data and information is acquired and provided. The application also specifies the intended use and the requirements or expectations concerning credibility, accuracy and transparency. This Technical Specification gives specific guidelines when the application implies a comparison between quantitative environmental information about different products, processes or systems.

4.2 Internal use of quantitative environmental information

This Technical Specification gives guidelines for the acquisition and provision of quantitative environmental information for internal applications. Typical applications are as follows:

- monitoring of environmental performance indicators; acquisition and provision routines for the repeated information handling tasks required for documentation and support the continual improvement of the environmental management system;
- environmental risk assessment; quantified environmental information about identified risk factors and possible impacts as intended or accidental;
- life cycle assessment studies of products and services (LCA); data acquisition procedures for acquisition and provision of life cycle inventory (LCI) data for internal use are required;
- material flow cost accounting (MFCA); quantitative information on material and energy flows on the process level of an organization to be acquired and provided in order to improve resource efficiency of production systems;
- business intelligence; quantitative methods and routines for the assessment of environmental performance and requirements for the general market need to be specified.

Ideally, the routines for acquisition and provision of the different applications are based on one general set of guidelines to ensure consistency between different applications and also to ensure the maximum usability of the acquired and provided information.

4.3 External use of quantitative environmental information

This Technical Specification also gives guidelines for the acquisition and provision of quantitative environmental information for external applications, such as the following:

- greenhouse gas (GHG) trading scheme and GHG emission reporting;
- corporate environmental and sustainability reporting;
- governmental reporting;
- external communication, such as eco-labelling, environmental product declarations and other public life cycle assessments, by providing guidelines on how to specify requirements on transparency, accuracy and other aspects that are important when communicating results of complex studies externally;
- environmental performance reporting, such as setting the quantitative specifications for the reporting of the eco-efficiency of products and services of a company.

Any external application that uses quantified environmental information demands consistent, reliable and transparent acquisition and provision routines. These are based on one general set of guidelines to ensure credibility and reproducibility of such data. Information that is acquired and provided following one general set of guidelines can be more easily used by different external applications, thus reducing or avoiding parallel data acquisition.

4.4 Using quantitative environmental information for comparisons

This Technical Specification gives specific guidelines when the quantitative environmental information is intended for comparisons, such as the following:

- comparing carbon dioxide emissions from different production plants;
- comparing eco-efficiency of different products;

— comparing life cycle impact assessment of different functional units;

— comparing electricity consumption by different production units.

When acquiring and providing data intended for comparison, it is important to consider not only the application at hand, but also that any decisions are generalizable and repeatable when acquiring the same or similar data for the other system(s) for comparison.

One of the objectives of quantitative data may be to carry out comparative studies, such as the following:

a) comparison of a system at two or more different time intervals;

b) comparison of the effect of changes in systems, areas and product lines;

c) comparison of different organizational and operational boundaries internally or externally.

5 Principles for generating and providing quantitative environmental information

5.1 General

These principles are fundamental for ensuring that quantitative environmental information provides a true and fair account and is used as guidelines for decisions relating to this Technical Specification.

5.2 Relevance

Ensure that selected data sources, system boundaries, measurement methods and assessment methods meet the requirements of the interested parties and/or the application.

NOTE These requirements can vary for different interested parties and different applications.

5.3 Credibility

Provide quantitative environmental information that is truthful, accurate and not misleading to interested parties.

5.4 Consistency

Develop compatible, coherent and not self-contradictory quantitative environmental data and information using recognized and reproducible methods and indicators, which respect related integrity constraints.

5.5 Comparability

Ensure that the quantitative environmental information is generated, selected and provided in a consistent way, with consistent measurement units, thereby allowing for comparisons.

EXAMPLES Comparison of environmental performance of an organization over time; comparison of environmental performance of different organizations.

5.6 Transparency

Make the processes, procedures, methods, data sources and assumptions for providing and generating quantitative information available to all interested parties.

NOTE This is in order to ensure a proper interpretation of the results and to give explicit reasons for any extrapolations, simplifications or modelling performed, taking into account confidentiality of information, if required. In addition, any volatility or uncertainty is disclosed.

5.7 Completeness

Reflect all significant quantitative environmental information for the intended use, in such a way that no other relevant information needs to be added.

5.8 Accuracy

Minimize uncertainties as far as practicable and eliminate tendencies towards a particular perspective or bias.

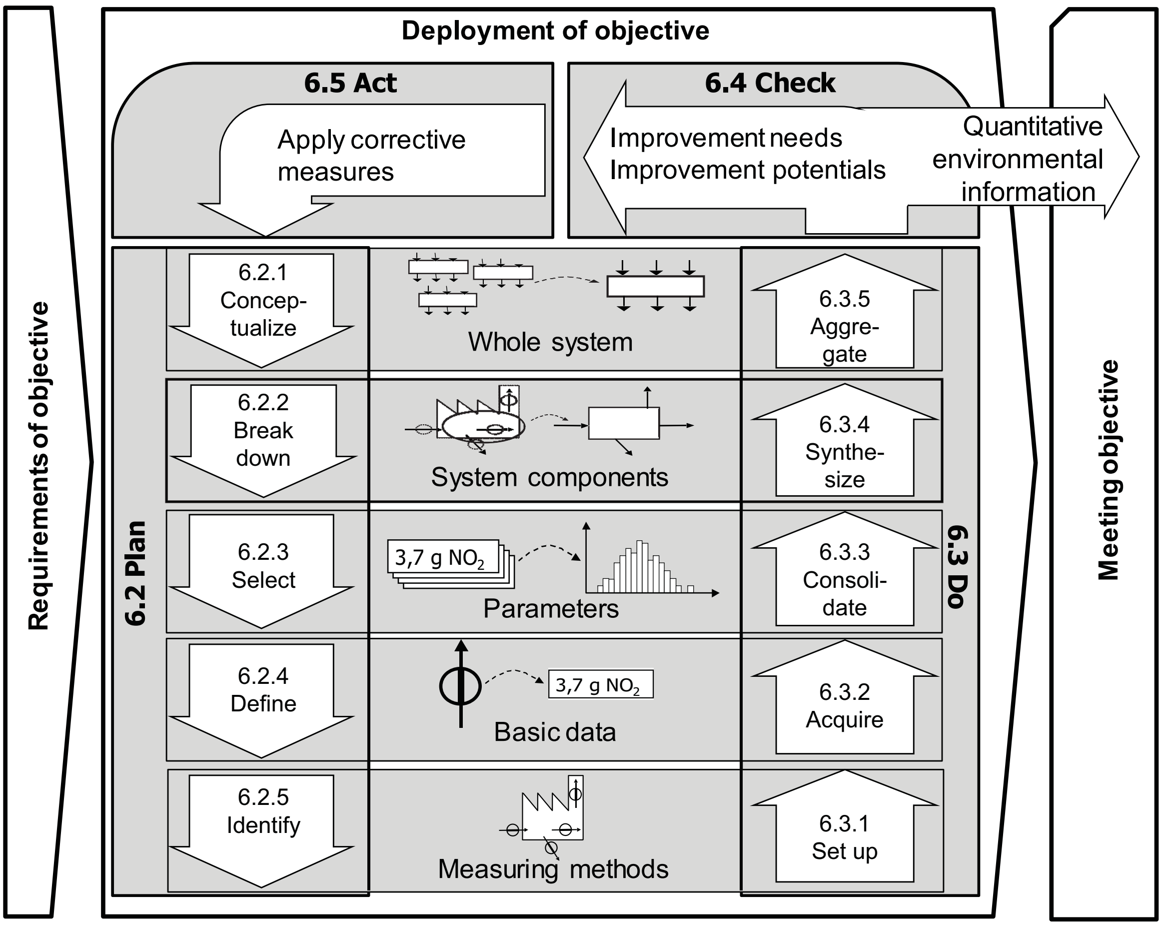
5.9 Appropriateness

Make quantitative environmental information relevant and fully understandable to interested parties, by using formats, language and media that meet their expectations and needs.

6 Guidelines

6.1 General

The guidelines in this Technical Specification are based on the methodology known as Plan-Do-Check-Act (PDCA), as illustrated in Figure 1.



NOTE The numbers in the figure refer to clauses and subclauses in this Technical Specification.

Figure 1 — Guidelines for acquiring and providing quantitative environmental information in accordance with the Plan-Do-Check-Act methodology

The emphasis of the guidelines lies in tasks which belong to Plan and Do. Each task of Plan corresponds to a task in Do. This covers the handling of specific issues down through the planning and data acquisition, up to the provision of the quantitative environmental information.

Although the process may appear straightforward, data aggregation for the whole system may require iterative steps in planning and doing, such as defining basic data requirements, modifying measurement systems, and use of additional data analysis tools. Even if not always expressed explicitly, the handling of secondary or other external data is covered by the guidelines.

The guidelines, as described in Figure 1, support a process view. The guidelines distinguish the three consecutive phases:

- requirements of objectives,
- deployment of objectives, and
- meeting objectives.

The focus of the guidelines is on the middle phase, the deployment of objectives. In this phase, the quantitative environmental information is prepared and delivered according to the requirements of the objective. The aim of the process of the guidelines is to meet the objectives by consecutively planning the acquisition of information and data and consecutively acquire, compile and provide the quantitative environmental information. The objectives are met by following the internal Plan-Do-Check-Act process of this phase, if necessary in the form of a continual improvement.

In practice, the guidelines may be approached from three viewpoints, as follows:

a) top down, as detailed guidelines for specifying quantitative environmental information for one or several defined applications, where it gives guidelines towards stepwise increase of specification (see 6.2, Plan);

b) bottom up, as stepwise guidelines for how to compile basic data into quantitative environmental information intended for given applications (see 6.3, Do);

c) from the viewpoint of guidelines about what and how to check and review quantitative environmental information (see 6.4, Check).

The guidelines relate to the application of quantitative environmental information. The application sets the requirements and defines the intended use of the information. The guidelines do not include the application.

In 6.2 to 6.5, the guidelines are presented top down, starting with Plan. Supplementary guidelines and examples of applying the guidelines are given in Annex A.

6.2 Plan

6.2.1 Conceptualize whole system

Conceptualizing the whole system involves understanding the basis for the collection of the quantitative environmental information. This includes the following:

- the objective of the information and intended use;
- the object on which information is to be provided;
- system boundaries;
- interested parties and target audience;
- requirements for the general quality of the information.

EXAMPLE For a public sustainability report, the yearly energy use for all heat treatment units is compiled, from gate to gate. The yearly energy use can be given both in terms of total energy use, in megajoules, and types of energy purchased. The energy use data in the sustainability report are also used to follow up performance tracking. The yearly energy use can be calculated by aggregating all heat treatment units. The publication format requires an average to be calculated for the heat treatment unit.

6.2.2 Breakdown system components

Breaking down into system components means dividing the object (described in 6.2.1) into manageable components. This can be done iteratively in order to reach a level where parameters can be selected.

The breaking down into system components can be performed on the basis of different aspects, for example:

— activities, functions and processes performed by the system,

— operational, technological, temporal, geographical or other features of the system,

— organizational, economic or responsibility structures and boundaries of the system,

— physical properties, for example transformation, transportation, capability to build up stocks,

— species, eco-systems, media types and internal material transportation within, into and out from the system, and

— indicators, aspects, inputs, outputs and stocks of the system.

When performing system breakdown for a comparison application, it is essential that the individual system components are functionally comparable with the system components of any of the systems intended for comparisons.

EXAMPLE Identifying each specific heat treatment unit and clarifying their respective system boundaries.

6.2.3 Select parameters

Selection of parameters means identifying quantifiable entities of a system component that represent quantified data. The parameters chosen are those needed to perform calculations and aggregations.

Different types of parameters can be chosen from system characteristics, e.g.:

— technical: activity data, production data, geographical data, energy data and emission data;

— ecological: biodiversity data, habitat data, nutrient data and biological data;

— socio-economic: demographic data, health data, development status data and economic data;

— other factors.

When selecting parameters for a comparison application, it is essential that the environmental significance of the individual parameters is comparable with the environmental significance of the parameters of any of the systems intended for comparisons.

EXAMPLE From an analysis of the economic bookkeeping, it is concluded that the major energy purchases are electricity and natural gas for all heat treatment units. Therefore, a decision is made to acquire data for the two parameters: electricity and natural gas.

6.2.4 Define basic data

Defining basic data means describing the data needed to quantify each parameter selected as described in 6.2.3. This includes the following:

- which basic data are needed to obtain the quantitative value for the parameter;
- how the basic data are transformed into quantitative value for the parameter;
- the scale of precision and statistical representativeness.

Basic data are defined in order to fulfil the quantity and quality requirements of the objectives of the intended information. This also includes the selection of the appropriate statistical or numerical guidelines for subsequent analysis and synthesis into useful data.

Basic data differ depending on which object, which property and which scale of precision is intended. When defining basic data for a comparison application, it is essential that any comparable basic data are equally defined for any of the systems intended for comparisons.

EXAMPLE The basic data needed is electricity consumption data. Electricity consumption data from different time periods will be combined into a consumption value of the whole year. Due to high fluctuations in electricity consumption, the highest possible sampling frequency needs to be used.

6.2.5 Identify measuring methods

Identifying measuring methods involves describing how to acquire the basic data with the required scale of precision and statistical representativeness, as described in 6.2.4.

The measurement method depends on the object from which data are acquired, on the property data about which they are acquired, and on the required scale of precision of the basic data. The measurement method should be suitable regarding the definition of the basic data. Methods may be selected based on available standards, literature and/or expert advice.

When identifying measurement methods for a comparison application, it is essential that these measurement methods provide comparable results for the systems intended for comparisons.

Part of the definition of the measuring method is the data quality assurance associated with the measuring method, e.g. establishing baselines, calibration or validation of equipment or measuring system and verification of data collected.

EXAMPLE Identifying the measuring points where the electric meters need to be installed at each heat treatment unit. The meters can be equipped with a logging function connected to a database for the log-file.

6.2.6 Primary and secondary data sources

A collection of data specifically for the task at hand is referred to as a primary data source. Data collected for another task, but which is useful for the task at hand, is referred to as a secondary data source.

Primary data source may for example be acquired by optically reading of meters and diagrams, collecting electricity and raw material bills, collecting laboratory samples/performing laboratory analysis or by producing/running calculation models. Secondary data source may be collected by acquiring literature and databases or by consulting experts.

For secondary data, the key question is to choose those which are sufficiently representative for the intended use. For secondary data sources, there can be an assessment of the credibility of the data source, the relevance of the data and the sufficiency of the data for the purpose.

EXAMPLE 1 An example of choice of secondary data sources is fuel consumption that can be derived from literature providing data about technical estimations of fuel consumption at different effect levels for that type of technology.

For primary data, there are several key parameters depending on the data to acquire, such as the following:

- choice of methodology;
- location for the measurement;
- choice of entity to sample;
- sample frequency.

EXAMPLE 2 An example of choice of primary data sources is fuel consumption that can be derived from economic data for fuel-bills or from fuel flow measurements.

6.3 Do

6.3.1 Set up measuring methods

Measurement methods are set up according to Plan in 6.2.5. Sometimes the necessary measurement equipment and routines are already in place and only need to be identified. In some cases, adaptation of existing measuring systems may need to be carried out.

Estimate significance of any deviation of Plan and, if needed, use corrective values or establish corrective routines.

EXAMPLE 1 A high frequency logging electricity meter is installed on a cable feeding only the production unit studied. The logging data is stored in a database, with electricity consumption logged every half second, each log value supplied with a data and a time stamp.

EXAMPLE 2 A meter measuring a certain contaminant needed to be moved a certain distance downstream from its intended position. As a result, the probe measures a lower concentration than intended of the contaminant due to dilution. A correction value is introduced to transform measured concentration to actual concentration at the intended measurement point.

6.3.2 Acquire basic data

Basic data are acquired according to the measurement method. Disturbances in measurement and estimations of the significance of these disturbances are expressed in terms of uncertainty.

EXAMPLE The sampling values of the instantaneous electricity consumption are stored in a log file. The overall electricity consumption is calculated by integrating the sampling values over the time period of one year.

6.3.3 Consolidate parameters

Parameters are consolidated according to Plan, as described in 6.2.3. If data processing differs from Plan, the deviation is explained together with an estimation, evaluation or analysis of its significance. Significances are estimated iteratively, starting with a qualitative analysis that subsequently can lead to a thorough statistical analysis of uncertainty.

EXAMPLE 1 It was intended to obtain the previous month's electricity consumption, but measurement during the previous month failed, so it is decided to use the previous year's measurement for the same month as data source. An estimate of the error is made based on changes in production volume and other influencing parameters, e.g. outside temperature. The significance of this error is considered relevant. Therefore, a corrective value of plus or minus a certain percentage is applied.

EXAMPLE 2 Transform cubic metres into normalized cubic metres.

6.3.4 Synthesize system components

System components are synthesized according to Plan, described in 6.2.2. To synthesize the system components, the parameters consolidated as described in 6.3.3 are related to the parameters of each system component, as described in 6.2.2.

The parameters selected according to 6.2.3 that have different origins may not have a defined relationship with each other. The synthesis aims at defining this relationship to coherently describe the resulting system component. The relationships between the parameters may be established on the basis of mechanistic or other physical or chemical relationships, synchronization of timeline, logic or other relevant causalities.

If there are deviations from Plan, such as a lack of data on system components, the significance is estimated and corresponding measures are taken. Examples of corresponding measures could be to accept the lack or to make a rough estimate, both associated with an uncertainty measure.

EXAMPLE Reporting of energy use per year for a heat treatment unit. The inflow of natural gas is measured through data in the invoices. The electricity consumption is measured by an electric meter installed at the heat treatment unit. These two different measured data are synthesized into a system component of one year of operation in terms of electricity consumption for that year and natural gas consumption for the same year.

6.3.5 Aggregate whole system

The whole system is aggregated according to the objectives, as described in 6.2.1. The system components are aggregated according to the appropriate aggregation type.

If there are deviations from Plan, such as lacking data on system components, the significance is estimated and corresponding measures are taken. Examples of corresponding measures could be to accept the lack or to make a rough estimate, both associated with an uncertainty measure. Depending on the magnitude of the significance, corresponding measures may not be sufficient. Instead, the plan may be corrected according to factual elements.

EXAMPLE The yearly energy use for all heat treatment units is aggregated by aggregating the electricity and aggregating the natural gas, from which the yearly average energy use is derived. This yearly average is expressed both in terms of electricity consumption and natural gas consumption separately, and in terms of total energy use in megajoules.

6.4 Check

Reviews, whose purpose is to ensure that Plan and Do follow the same approach and methodology for each of the different conditions that are to be compared, may be done at each task, or may cover several tasks throughout the work process. Such a review covers the planning (see 6.2, Plan) and the data acquisition, processing and provision (see 6.3, Do) as well as the monitoring, comparison and evaluation (see 6.4, Check).

The review of the planning stage may check whether the specifications are correct with regards to the application. The review of the data acquisition, processing and provision stages may check whether the specifications defined in planning have been followed.

If the review results in a conclusion that the acquisition and provision of the information is performed in line with the specifications, then the quantitative environmental information can be provided in accordance with the objective. Otherwise, new planning may be needed.

Any quality assurance observations may assist in the review of the overall quantitative environmental information acquisition and provision process. The improvements to be identified and implemented are both improvements of the methods and processes, and of the data and information as a result from iterations.

6.5 Act

Based on the results from Check, necessary actions are taken to continually improve the acquisition and provision process.

Annex A
(informative)

Supplementary guidelines, examples and case studies

A.1 Illustrative examples for applying the guidelines

A.1.1 Examples of deployment of the objectives in 6.2 and 6.3

This clause provides general illustrative examples for the different stages of the deployment of the framework objectives presented in Clause 6. The examples are grouped in Plan-Do pairs at the same vertical level, as presented in the framework in Figure 1. This means that examples in 6.2.1 and 6.3.5 constitute the first pair, those in 6.2.2 and 6.3.4 constitute the second pair, etc., with the last pair being 6.2.5 and 6.3.1. The text gives examples of what type of information activity is planned and also done at each level.

A.1.2 Conceptualize whole system (see 6.2.1) and aggregate whole system (see 6.3.5)

A.1.2.1 This subclause gives examples of aspects to consider when conceptualizing the whole system to acquire and provide quantitative information about it, as well as examples of aspects to consider when eventually aggregating the whole system to provide quantitative information about it.

A.1.2.2 Examples of target audience of the information are as follows:

- authorities;
- customers;
- environmental coordinators;
- third-party reviewers;
- product designers.

A.1.2.3 Examples of intended use of the information are as follows:

- internal reporting or decisions;
- reporting to authorities;
- market claims;
- knowledge build-up.

A.1.2.4 Examples of the object about which to provide information are as follows:

- quantitative properties of a system or a process, such as a production unit or a product life cycle;
- quantitative properties of specific species in an eco-frame;
- amounts or flows of substance, such as inputs and outputs;
- quantitative properties of an organization;

- sectorial average process;
- multi-media models for impact assessment;
- functional units or values;
- costs;
- eco-efficiency;
- product or service;
- temporal, sectorial and geographically averaged data.

A.1.2.5 Examples of system boundaries are as follows:

- organizational unit;
- production site;
- production process;
- product life cycle;
- product life cycle, from cradle to gate; and
- waste water pipe.

A.1.2.6 Examples of specific quantitative requirements are as follows:

- describe and quantify a system:
  - quantification and location of hot-spots and significant aspects;
  - quantification of the total CO_2 emission for an organization;
  - quantification of a sectorial average process, including the specification of its significant inputs and outputs;
  - quantification of the different weights to the individual process data from different production units when forming a new sectorial production average;
  - quantification of a life cycle cradle-to-gate inventory profile including the life cycle cradle-to-gate flow chart with site-specific data for all constituting processes;
- compare different systems:
  - provide quantitative comparative information about system A and system B;
  - quantify how much better or worse environmental performance process A has in comparison to process B;
  - provide quantitative information about how many species are found in a studied eco-frame during a specific period;
  - provide quantitative information about whether the number of species in the studied eco-frame has decreased or increased compared to a previous period, as well as quantitative information about how many species there were in the two different periods;
  - provide quantification of an emission, a flow, a status or of any other quality.

A.1.2.7 Examples of requests for the general quality of the information are as follows:

- credibility requirements;
- review requirements;
- documentation needs;
- numerical precision;
- whether new data needs to be collected from physical measurements or whether generic data may be used.

A.1.2.8 Examples of aggregations leading to a quantitative result are as follows:

- temporal average: data about a process from different time intervals is aggregated into an average over a more general time interval;
- product category average: material content of different but similar products is aggregated into an average material content for a common product category.

A.1.2.9 Examples of aggregations leading to a categorical result are as follows:

- based on quantitative comparisons, the result is a qualitative preference stating which system is the better;
- based on quantitative comparisons, the result is priority ranking of different environmental aspects.

A.1.2.10 Examples of quantitative system model aggregations are as follows:

- combined aggregations, where sectorial and temporal averaged data, and life cycle inventories based on temporal, sectorial and geographically averaged data, are used to model a whole system;
- to aggregate a full eco-frame, it may be necessary to combine different models of different media, such as air, water and soil into a combined multi-media model;
- to quantify the eco-efficiency of a product or service, a quantitative value of the functional value of the product or service is divided with a quantification of the environmental external cost of the same product or system.

A.1.2.11 Examples of a new system model (several interrelated systems are aggregated into a new system) are as follows:

- life cycle inventory: different processes are linked through their inputs and outputs into a larger aggregated process;
- environmental multi-media model: different partial eco-system media models are linked into a combined multi-media model;
- sectorial average: data from different processes are aggregated within the same sector into an average for processes within the sector;
- department, company, etc. are aggregated into an organizational model.

A.1.2.12 Any combination of A.1.2.1 to A.2.1.11 is possible.

A.1.2.13 Comparison, by subtraction or ratio, such as:

- eco-system change: the status of an eco-system is compared at two different time intervals by subtraction;
- eco-efficiency: the values gained by a system are compared with the external costs caused by the same system.

A.1.3 Breakdown system components (see 6.2.2) and synthesize system components (see 6.3.4)

This subclause gives examples of aspects to consider when breaking down the data acquisition into manageable smaller tasks, and when combining the acquired data items into system components to aggregate.

Examples relating to breaking down system components are as follows:

- to produce a consistent model of inputs and outputs for a production unit, data for different raw material purchases, electricity bills, waste management bills and production data need to be combined with laboratory data about emission releases and sales figures;
- to produce a consistent carbon footprint of the product model from cradle to gate, the carbon dioxide emissions and carbon dioxide equivalents from each process throughout the whole supply chain need to be connected into one chain that together constitutes the resulting system.

A.1.4 Select parameters (see 6.2.3) and consolidate parameters (see 6.3.3)

This subclause gives examples of aspects to consider when selecting parameters to acquire data about each system component, as well as how to consolidate the acquired data into quantified parameters of the systems components.

Basic data typically originate from different data sources. Some are acquired as quantitative figures and units, such as the amount of a specific emission or the amounts of all inputs and outputs of one production process, while others come in forms that need to be consolidated to be meaningful and relevant. Examples of the latter are electricity bills that need to be reformulated as inflows of electricity, raw measurement log files that need to be transformed into numerical data, and data that is formed from combining different literature sources and databases.

This explanation may be in the form of reference to standard methods or literature. The methodology used may include the combination of several measurement results, or the selection of only a portion of the data collected, in order to obtain the intended parameter. Examples of this are the use of averaged data and discarding data falling outside a specified range of values.

a) Examples of selection of parameters are as follows:

   - when identifying environmentally significant parameters for a category of products, such as including nuclear waste and CO_2 emissions in the inventory of an electric hydro power plant, to make the quantitative result comparable with other ways to produce electric power;
   - only greenhouse gas emissions are relevant when the application concerns GHG or carbon footprinting, while a full set of emissions is relevant to conduct LCA or emissions reporting;
   - the total amount of hazardous waste relevant for official reports compared to the total amount of only waste oil;
   - the total amount of heavy metals used in a equipment compared to the total amount of cadmium;
   - the total amount of construction and demolition waste that exceeds aggregates.

b) Examples of consolidation are as follows:

- several alternative quantitative estimates about the emission from a specific type of furnace: assign different probability or relevance weights to each estimate and produce one weighted average as quantitative data for the emission;
- several alternative quantitative system models describing resource use, emissions, waste generation and production from a type of industrial process: assign different probability or relevance weights to each system model, and maybe also to input and output data, and produce a new system model based on a complex weighted average of the basic data;
- several bird-count reports from a specific geographic area: assign different situation-, site- and time-related weights to each bird-count report, and produce a combined quantitative data based on a weighted average, taking into account duplication in the geographic area and different activity levels in daylight and at night time.

c) Examples of detailed aspects to consider during consolidation are as follows:

- calculations based on activity data multiplied by emission or removal factors, i.e.
  - the use of models,
  - facility-specific correlations, and
  - mass balance approach;
- measurement, either
  - continuous, or
  - intermittent;
- a combination of measurement and calculation.

A.1.5 Define basic data (see 6.2.4) and acquire basic data (see 6.3.2)

This subclause gives examples of aspects to consider when defining and acquiring basic data, both single basic data and data consisting of several interrelated data such as data about production units.

Table A.1 — Examples of acquiring single value data

Object	Physical property	Scale of precision
Waste water pipe of a production plant	Mass flow of waste water	Sampled daily by flow meter at site
Mass flow of waste water in a waste water pipe of a production plant	Biochemical oxygen demand (BOD)	Sampled daily at site, measured according to a standard model in a sample of waste water
Production plant	Number of products produced	Estimate from market size
Chemical process	Amount of oxygen consumed	Estimate from economic records
Production plant	Amount of specific material consumed	Estimate from material flow analysis
A specific product	Mass of a specific material	Parts per million of total weight
Transport to and from production site	Amount of emission to air of a specific substance	Average, based on generally acknowledged and credible estimate
A certain equipment	Amount of electric energy consumed	Based on marked effect and estimated use
A specific lake	Concentration of heavy metal in water	Based on measurements and reported as a representative yearly time series
General urban area	Mass per m^2 of dust fall	Based on distribution models. A flat average within the 90th percentile
Section of railway in domestic area	L_{EQ} of noise at a specific point of distance from the sound source	Based on actual measurements from typical trains passing
Drainage pipe from waste landfill	Throughput of liquid per second	To be measured at one minute each day between 11:59 and 12:00 every day and averaged into yearly throughput
Forest area	Number of woody stemmed plants greater than 2 m in height per unit area	Manually counted within $\pm$10 cm using benchmark stick at randomly selected and statistically significant number of samples of size 100 m $\times$ 100 m areas within the forest area
Forest area	Number of ant species	Manually counted through field studies by insect specialist
Company car pool	Amount of fuel consumed in car pool	Estimated from registered fuel efficiency and distances run of each car in pool

Table A.2 — Examples of modular data

Object	Physical property	Scale of precision
A specific production site	All environmentally significant inputs and outputs	Precision of each input and output based on single measured values
A specific type of processes	All environmentally significant inputs and outputs	Precision based on single measured values at production sites and averaged to type process value

Table A.3 — Examples of technological data

Object	Physical property	Scale of precision
Activity data	Resource use, emissions, waste, spill and products	Site-specific measurement during specified time interval
Production data	Raw material and electricity consumption, spill, waste and production	Continuous measurement at site
Geographical data	Position, altitude and area	GPS and altimeter logging
Emission data	Concentration of pollutant	Precision of laboratory analytical method

Table A.4 — Examples of ecological data

Object	Physical property	Scale of precision
Biodiversity data	Species and number of individuals of each species	Species identification with reference to a standard sample and counts of species within a defined transect line and area of measurement
Habitat data	Number of inhabitants in habitat	Average for selected species
Nutrient data	Concentration of nitrate, nitrite, phosphate	Precision of laboratory analytical method
Biological data	Biochemical oxygen demand (BOD)	Sampled daily at site, measured according to a standard model in a sample of waste water

Table A.5 — Examples of socio-economic data

Object	Physical property	Scale of precision
Demographic data	Share of different demographic populations	Statistical sample interviews
Health data	Infant mortality rate	National statistics
Development status data	Share of adult population who can read and write	Estimations
Economic data	GDP growth	Trade statistics

Examples of deviations to plan that may occur when acquiring basic data are as follows:

- automatic logging may fail, resulting in parts of time series being missing;
- measurement instruments may be prone to reading difficulties; hence the value may be biased;
- time-stamps of economic records, such as delivery date, invoice or payment, might not be synchronized with physical time;
- it may be difficult to interpret representativeness of data from life cycle inventory databases, partly due to the complexity of the data and partly due to the quality of the documentation of the data;

- it may be difficult to interpret representativeness and accuracy of data produced by calculation models and software, partly due to the complexity and documentation of the calculation models and software code, and partly due to the accuracy level of the input parameters to the model or software;
- consulted experts may supply typical basic data and typical deviations, but such data might not reflect the actual situation;
- acquisition is not according to the specified precision or the statistical requirements.

A.1.6 Identify measuring methods (see 6.2.5) and set up measuring methods (see 6.3.1)

a) Environmental inventory of a manufacturing plant: To define the electric consumption for one unit of product, the quantitative data for electric consumption of one manufacturing machine is related to the number of units produced during the same time period that the consumption is measured. The same applies to all data about resources, emissions and waste figures. All quantitative data are related on basis of temporal synchronization and physical relationships;

b) Environmental inventory of an organizational unit: The principle for performing an environmental inventory of an organization differs from the environmental inventory of a manufacturing by the importance of economic and organizational causalities rather than physical causalities;

c) Process data for use in a life cycle assessment study: Normalize all input and output data to a unit of a product provided by the process. If all or some of the input and output data also relates to production of other products, allocate the input and output data according to defined allocation rule;

d) An eco-system: Describe how measurement data is used to describe load, concentration increase and environmental sensitivity of an eco-system;

e) Environmental life cycle performance per yearly production volume 2007;

f) Carbon footprint of products in business area 2008;

g) Environmental performance on selected impact categories from a specific product or function.

A.2 Case studies with complete examples

Quantitative environmental information can be communicated through several report types, which have divergent approaches in considering aspects such as system boundaries, data sources, intended use of quantitative environmental information or gathering data and calculation process. In order to provide some examples, we can consider three main kinds of reports. These types are corporate reports, standardized reports, and ad hoc reports.

Table A.6 shows the main features of each report type regarding the mentioned aspects.

Table A.7 provides a generic example.

Table A.6 — Main features of different report types

Report type	System boundaries	Continuity in time	Data sources	Intended use	Gathering data and calculation process
Corporate reports Sustainability report Environmental report Environmental accounting	Whole reporting organization, at different levels: — local — regional — global	Continuous	Measurement systems Laboratory tests Delivery notes Invoices	Internal and external use	Statistical methods on measurement series Calculation Appliance of conversion factors
Standardized reports EPD Eco-labelling LCA MSDS	Product	Timeless	External database Supply chain	External use	Established methodology
Ad-hoc reports Flexible locations Temporary sites Others	Site and its environment Reporting organization, as an aggregation of sites	Not continuous Temporary	Measurement systems Estimates Expert outspoke; literature data Monitoring	Internal and external use	Statistical methods on historical data series Data gap adjustments with average values Appliance of conversion factors

Considering the characteristics suggested in Tables A.6 and A.7, some practical examples have been selected as case studies to cover the different kinds of processes. These examples attempt to illustrate the singularities of each process when collecting, calculating and communicating quantitative environmental information.

The case studies presented in Clause A.3 follow the structure given below:

— report type;

— data features;

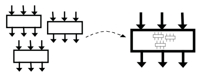
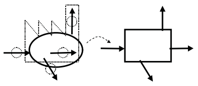
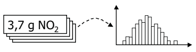
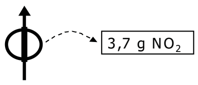
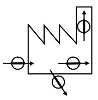
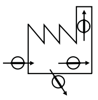
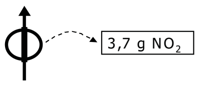
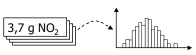
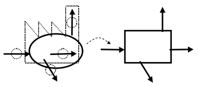
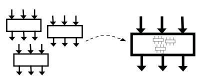
— data sources;

— responsibilities and duties during the process;

— results of the process;

— comments.

Table A.7 — Generic example

PLAN	
Whole system 	**6.2.1 Conceptualize** Quantitative consumption or emission of plant, organization, time period, (organizational and operational boundaries)
System component 	**6.2.2 Breakdown** Different possibilities: processes, areas, product lines
Parameters 	**6.2.3 Select** Identify measurement point to represent the quantity, e.g. electricity consumption meters, etc.
Basic data 	**6.2.4 Define** Define measurement point where parameter is to measured, including specific requirements on the measurements
Measuring methods 	**6.2.5 Identify** Frequency electric meter readings, where, quantity, quality assurance (QA)/quality control (QC) plan; electric meter/bills/equity share/historical
DO	
Measuring methods 	**6.3.1 Set up** Set up electric meters, QA/QC of setup, baseline, calibration, verification
Basic data 	**6.3.2 Acquire** Acquire data by reading meters, collecting bills, etc.; collect samples, analysis
Parameters 	**6.3.3 Consolidate** Statistical/data processing (formula calculations); aggregation/data management
System component 	**6.3.4 Synthesize** Calculating indicators, synthesize system model, assessing, validating
Whole system 	**6.3.5 Aggregate** Aggregate into a consistent report for intended purpose

A.3 Case study: data sources for quantitative environmental information in the construction sector

The following examples show a way to collect and process quantitative environmental information in the construction sector in two different contexts: a single work site (in Table A.8) and a whole company (in Table A.9). These examples could follow the same pattern and encounter common issues, but in order to provide a more complete picture for this case, two examples in different contexts with different issues are provided.

Table A.8 — Data sources for quantitative environmental information in the construction sector: Single work site

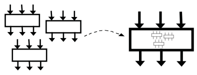
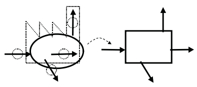
PLAN	
Whole system 	**6.2.1 Conceptualize** The work site will be the system for which we are going to collect environmental data in this example.
System component 	**6.2.2 Breakdown** We identify the main components of the selected system which will be analysed later. They can be as detailed as needed: • Atmosphere: - dust emissions; - fuel gas emissions; - VOCs (volatile organic compounds) and CFCs (chlorofluorocarbon) emissions; - night light; • Noise and vibrations: - noise; - vibrations; • Effluent discharges; • Occupation of rivers or sea beds and water abstraction; • Occupation, pollution or loss of soils; • **Use of natural resources (1):** - water consumption; - fuel consumption; - electric energy consumption; - concrete consumption; - asphalt agglomerate consumption; - steel consumption; - earth consumption; - vegetal soil consumption; - dangerous substances storage and handling; • **Waste generation (2):** - generation of hazardous waste; - generation of non-hazardous waste; - generation of inert waste; - generation of municipal waste. • Radiation emissions; • Land planning and urban environment planning. For this example, we will use the system components in bold.

Table A.8 (*continued*)

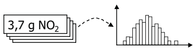
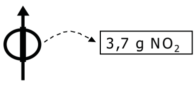
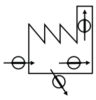
PLAN	
Parameters 	**6.2.3 Select** For two different system components of those above mentioned, we could select several parameters, e.g. • 1. Use of natural resources (water): - re-use of aggregates from other work sites; - use of recoverable elements in site processes for example removable walls in aggregates crushing installations; - reduction of loans compared to the volume forecasted in the project; - **re-use of waste and residual waters from processes (P1);** - re-use of removed topsoil; - usage of elements recovered from other projects, for example portable water treatment plants, containers. • 2. Waste generation: - reduction of aggregates taken to tip compared to forecasted volume in project; - classifications/separation of waste from building and demolition for individual handling; - changes in the design or in the building system with regard to the use of materials that generate dangerous waste such as asbestos, de-coffering liquids, additives, resins, varnishes, paints, etc., generating waste of less or no danger; - reduction of packaging waste through practices such as requesting materials with packaging that is returnable to the supplier, re-use of polluted packaging, reception of elements in bulk that are normally provided in packages; - **management of waste from excavation (P2);** - valuation of rubble. The parameters selected for each system component are P1 and P2 (in bold). For this example these parameters quantify preventive environmental measures implemented on site.
Basic data 	**6.2.4 Define** In order to calculate the selected parameters, we need to define some data, e.g. • P1. Re-use of waste and residual waters from processes: - cubic metres displayed on flow meters. (amount of residual waters that pass through the pipe expressed in units of volume) • P2. Management of waste from excavation: - tonnes and cubic metres of waste in the work site, for each possible destination. (Managed amount of waste from excavation expressed in units of volume, cubic metres or units of mass, and different destinations for them: reuse on site or on other work sites, recovery, landfill.)
Measuring methods 	**6.2.5 Identify** After clarifying the needed information to collect, it is time to identify the methods to obtain this data: • P1. Re-use of waste and residual waters from processes: - The method to obtain the basic data for this parameter will be the displayed data of the flow meters distributed in different locations of the work site. The type of flow meter installed has to be taken into account, considering two types: cumulative flow meter (displays the total amount of water) and instantaneous flow meter (displays the amount of water at each moment). • P2. Management of waste from excavation: - In order to measure the amount of waste from excavation in cubic metres or tonnes, we can apply different methods such as: a. Delivery notes and invoices from carriers or waste managers or number of trucks which transport this waste and its freight capacity. With this method we obtain cubic metres or tonnes. b. Estimations and measurements of the waste volumes by technical experts on site (topographer, engineer, etc.). With this method we can obtain cubic metres.

Table A.8 (*continued*)

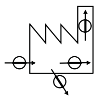
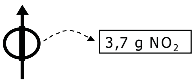
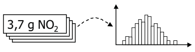
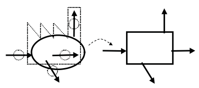
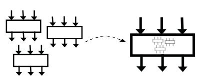
<table>
<tr><th colspan="2">DO</th></tr>
<tr><td>Measuring methods
</td><td>6.3.1 Set up
• P1. Re-use of waste and residual waters from processes:
- installation, calibration and verification of flow meters.
• P2. Management of waste from excavation:
- person to count trucks, asking for delivery notes or making estimations once a week.</td></tr>
<tr><td>Basic data

</td><td>6.3.2 Acquire
• P1. Re-use of waste and residual waters from processes:
- auto-read flow meters every 5 min (instantaneous flow meter) or daily, weekly, monthly (cumulative flow meter).
• P2. Management of waste from excavation:
- read delivery notes, invoices and expert's reports.</td></tr>
<tr><td>Parameters

</td><td>6.3.3 Consolidate
• P1. Re-use of waste and residual waters from processes:
- calculate the percentage of residual waters which are reused from the process.
• P2. Management of waste from excavation:
- calculate the percentage of waste from excavation which is transferred to the different destinations.</td></tr>
<tr><td>System component
</td><td>6.3.4 Synthesize
The synthesis of the results can be made, for instance, assigning two coefficients to each parameter (importance and degree of implementation). We can assign the coefficients based on experts, suggestions, bibliography, work site experiences, etc. The product of these coefficients provides a score. The total addition of the product of these two numbers in each parameter is the total score for the work site.
The coefficients 1, 2 or 3 can, for example, be assigned to importance and degree of implementation:
• P1: characterized by the importance and the degree of implementation, depending on the percentage of residual waters reused from the process (>15%, >30% or >60%);
<table>
<tr><th rowspan="2">Identification</th><th rowspan="2">Importance</th><th colspan="3">Goal (degree of adoption)</th></tr>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Re-use of waste and residual waters from processes</td><td>2</td><td>>15%</td><td>>30%</td><td>>60%</td></tr>
</table>
• P2: characterized by the importance and the degree of implementation depending on the percentage of waste from excavation which is used on another site or for restoration of a degraded area (>1%, >30% or >50%).
<table>
<tr><th rowspan="2">Identification</th><th rowspan="2">Importance</th><th colspan="3">Goal (degree of adoption)</th></tr>
<tr><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Management of waste from excavation</td><td>2</td><td>>1%</td><td>>30%</td><td>>50%.</td></tr>
</table>
Depending on the degree of adoption, which is calculated based on the acquired basic data; the product of the coefficients can be calculated. This provides a result for the system component.</td></tr>
<tr><td>Whole system
</td><td>6.3.5 Aggregate
Effluent discharges: Percentages, importance, degree of implementation and the result of the product between the importance and the degree of implementation.
Waste generation: Percentages, importance, degree of implementation and the result of the product between the importance and the degree of implementation.</td></tr>
</table>

Table A.8 (*continued*)

CHECK
Data accuracy should be ensured by a system of site support visits, internal and external audits and by the quality checks to which the data are subjected, at the site firstly, and at the subsequent various stages of data integration, secondly. The technical review of the inventory of environmental data is carried out at the following levels: - On site: checking lists, measurements, inspections and follow-ups; - Regional offices: review made in the support site visits; - Technical services: internal audits; and - External verifier to the organization: external audits. If environmental data are gathered at site level, the reviews performed by staff of the company regional offices, technical services and verifiers can be considered external to the site, whereas if the data are processed at corporate level, only the review involving verifiers is external to the organization.
ACT
The results of the different checks and reviews are fed back to the data suppliers on site, aiming to correct and improve the quality of the data and methods used in acquiring and providing the environmental information.

Table A.9 — Construction sector: Whole company

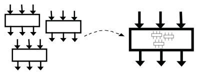
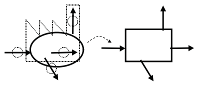
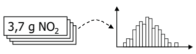
PLAN	
Whole system 	**6.2.1 Conceptualize** The whole company is chosen as the system that is going to be considered.
System component 	**6.2.2 Breakdown** We identify the main system components in which the activity of the whole company can be classified and later analysed. Different types of construction works could be considered: - Dams - Bridges - Roads - Railways - Pipelines - Sewerage systems Each of these construction works could consider different environmental issues, such as atmosphere, noise and vibration, use of natural resources, occupation, pollution or loss of soils and generation of waste. For this example we are going to choose “noise and vibration” and ”occupation, pollution or loss of soils” in the construction stage of a road.
Parameters 	**6.2.3 Select** Once roads are the type of construction work selected as the system component for this example, following parameters can be considered: • 1. Noise and vibration: - **Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc., (P3);** - Rubber lining in hoppers, mills, sieves, containers, buckets; - Consideration of environment conditions in the work programme; - Reduction of the effects of blasting; - Improvement over the levels required by law for controlled sound levels; and - Use of modern machinery; • 2. Occupation, pollution or loss of soils: - Restoration of the areas affected by site installations; - Limitation of the areas of access; - **Limitation of occupied areas (P4);** - Prevention of accidental tipping. A list of parameters based on environmental good practices can be defined for the system components. These parameters quantify preventive environmental measures implemented on site. The parameters selected for each system component are P3 and P4 (in bold). These parameters can be evaluated on the basis of two coefficients: the importance of the good practice and its degree of implementation. The product of these coefficients yields a score that can be considered a value of the site’s environmental performance. The data needed to obtain the final indexes may be, at first, mostly estimates falling within a reasonable range, provided by technical staff in charge of the acquisition of environmental data or by experts’ opinion. During the site life, these estimates are permanently verified, checked and adjusted.

Table A.9 (*continued*)

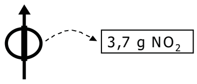
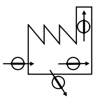
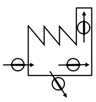
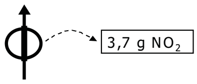
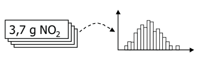
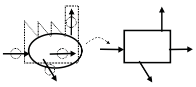
PLAN	
Basic data 	**6.2.4 Define** In order to calculate the selected parameters for all the roads of the company, we need to define some data from each work site. These data could be the following ones: • P3: Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers and shock absorbers: - a) Number of installations (shock absorbers, anti-noise barriers, etc.), - b) Number of machines with silencers or other devices installed, - c) Number of days when work site is active during the night. • P4: Limitation of occupied areas: - a) Written or graphical documentation of the areas occupied for different uses at the different work sites, aggregated by concepts such as machinery, personnel offices and stocks, - b) Signals and physical delimitations installed.
Measuring methods 	**6.2.5 Identify** • P3: Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc.: In the work site should be a report with the information about the equipment used and if they have special devices installed in order to reduce the noise and the vibrations (silencers, shock absorbers, etc.). In addition to this we should know the equipment which is working in each moment. With this information work site manager or experts could fill out the surveys. • P4: Limitation of occupied areas: We should know the design of the work site, maps, signals, physical barriers installed, etc. With this information experts or work site manager could fill out the surveys. Written or graphical documentation about the areas which could be occupied by machinery and/or personnel, existence of physical delimitation or signposting in the occupied area and information about if the occupied areas are limited strictly to the area occupied by the work site. Quantity of measures adopted in order to avoid or prevent unnecessary occupation of soils can also be considered. With this information work site manager or experts could fill out the surveys.
DO	
Measuring methods 	**6.3.1 Set up** • P3: Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc. - Programming surveys software and check the computers and the server for receiving the surveys. • P4: Limitation of occupied areas - Programming surveys software and check the computers and the server for receiving the surveys.
Basic data 	**6.3.2 Acquire** • P3: Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc. - Fill out the survey every 4 months • P4: Limitation of occupied areas - Fill out the survey every 4 months
Parameters 	**6.3.3 Consolidate** • P3: Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc. - Calculate the percentage of equipment with devices installed to reduce noise and vibrations, and calculate the number of days on which the work site has been active during the night. • P4: Limitation of occupied areas - Gather information about occupied areas, signalization and physical delimitation of them.

Table A.9 (*continued*)

DO

System component



6.3.4 Synthesize

The aggregation of the results of each work site into a global result for the whole company can be made, for instance, assigning two coefficients to each parameter (importance and degree of implementation). We can assign the coefficients based on experts´ suggestions, bibliography, work site experiences, etc. The product of these coefficients gives the score for each work site. The average of the product of these two numbers in each work site is the total score.

- P3: Characterized by the importance and the degree of implementation, depending on the percentage of critical equipment with anti-noise and anti-vibrations devices installed and the equipment used during the night.

Identification	Importance	Goal (degree of adoption)		
		1	2	3
Use of devices to reduce noise and vibration in installations or machinery on the site, with silencers, anti-noise barriers, shock absorbers, etc.	3	Presence of these devices in some equipment that is considered critical.	Idem, in 50% of the equipment considered critical and in 50% of that used at night.	Idem, in 100% of both critical equipment and that used at night.

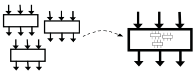
- P4: Characterized by the importance and the degree of implementation, depending on the delimited area (physical or not) and signposting.

Identification	Importance	Goal (degree of adoption)		
		1	2	3
Limitation of occupied areas.	1	There is written/graphical documentation of the areas that can be occupied by machinery and personnel.	In addition, there is physical delimitation or signposting of these areas.	In addition, these areas are limited to the area occupied by the site.

The coefficients 1, 2 or 3 can, for example, be assigned to importance and degree of implementation.

Depending on the degree of adoption, which is calculated based on the acquired basic data; the product of the coefficients can be calculated. This provides a result for the system component.

Whole system



6.3.5 Aggregate

Noise and vibration: Percentage of equipment with anti-noise and anti-vibration devices installed, number of days with activity during the night, importance, degree of implementation and the result of the product between the importance and the degree of implementation.

Occupation, pollution or loss of soils: Information of the limited areas, its limitation and signalization, importance, degree of implementation and the result of the product between the importance and the degree of implementation.

A.4 Limited/simplified example of environmental accounting system implementation

The example in Table A.10 shows a simplified example of environmental accounting system implementation at a heating and power company, using software-based data gathering and accounting tools. The numbers, including factors used, are not real values.

Table A.10 — Simplified example of environmental accounting system implementation

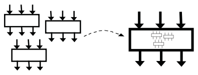
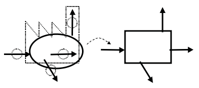
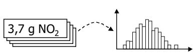
PLAN	
Whole system 	**6.2.1 Conceptualize** Objective: - Accounting of climate and energy aspects for energy production company Hafslund, Norway. Target: - Find air emissions per produced energy (mass/energy) System boundary: - Energy production business area only - Yearly from 2008 onwards - Quarterly from 2010 Intended use: - Continual monitoring of performance - Internal and external reporting
System component 	**6.2.2 Breakdown** Organization: - Level 1: Hafslund Group - Level 2: Business area - Level 3: Company - Level 4: Site Activities: - Heat production - Cooling production - Pellet production - Combined heat and power production Hydro power production: - Sources - Bio oil, biomass (wood chips), pellets - Electricity - Heating oil, LNG, propane - Municipal waste, commercial waste
Parameters 	**6.2.3 Select** Activity/input: - Total fuel(s) used (in megawatt-hours) - Total fuel(s) from renewable sources (in megawatt-hours) Climate gases: - CO_2 (in tonnes) Other air pollutants: - NO_x (in tonnes) - Dust (in kilogrammes) - SO_x (in tonnes) Production parameters: - Total produced energy (in megawatt-hours) Other parameters: - Total efficiency (# 0-1)

Table A.10 (*continued*)

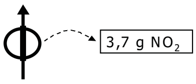
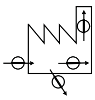
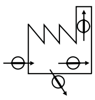
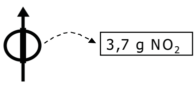
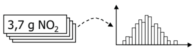
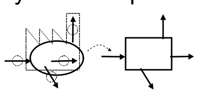
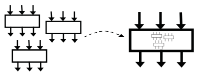
<table>
<tr><th colspan="2">PLAN</th></tr>
<tr><td>Basic data
</td><td>6.2.4 Define
Parameter inputs:
- Fuel oil (in litres)
- Bio oil (in litres)
- Electricity (in kilowatt-hours)
- Commercial waste (in kilogrammes)
- Biomass (in kilogrammes)
- Used energy from seawater/sewage (in megawatt-hours)
Factors:
- Energy contents (in kilowatt-hours per litre)
- Renewable shares (#)
- CO_2 emission factors (in kilogrammes per unit)
- NO_x emission factors (in kilogrammes per unit)
- Dust emission factor (in kilogrammes per unit)
- SO_x emission factor (in kilogrammes per unit)
Constants:
- Densities (in kilogrammes per litre)</td></tr>
<tr><td>Measuring methods
</td><td>6.2.5 Identify
Parameter inputs:
- Production databases
  - Oil flow (meters)
  - Biomass weighing (meters)
  - Energy from heat pump (meters)
- Energy management system
- Electricity bills
Factors:
- From reliable public sources (documented for each factor in portal accounting system)
- Energy contents from regular laboratory analyses and/or vendor specification</td></tr>
<tr><th colspan="2">DO</th></tr>
<tr><td>Measuring methods
</td><td>6.3.1 Set up
All measuring equipment already set up</td></tr>
<tr><td>Basic data
</td><td>6.3.2 Acquire
Parameter raw data acquired from production system outputs for whole year (example):
<table>
<tr><th>Site</th><th>Heat
MWh</th><th>Wood chips
t</th><th>Electricity
MWh</th><th>Oil
l</th></tr>
<tr><td>Site 1</td><td>6 004</td><td>2 052</td><td>8 957</td><td>506 587</td></tr>
<tr><td>Site 2</td><td>0</td><td>0</td><td>7 906</td><td>68 581</td></tr>
</table>
Data input into software solution (distributed input from each site):
Input data gathered for whole year:
• Combusted wood chips: 2 052 t
• Energy content: 3,50 MWh/t
• Total heat production: 6 004 MWh
Factor read from factor library:
• CO_2 factor word chips: 13 kg/MWh
• NO_x factor wood chips: 0,5 kg/MWh</td></tr>
</table>

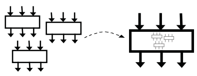
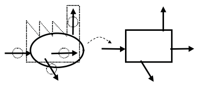
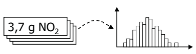
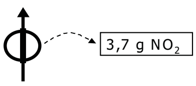
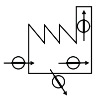
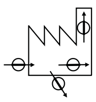
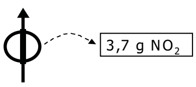
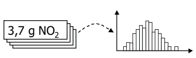
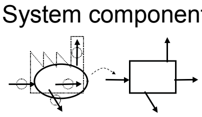
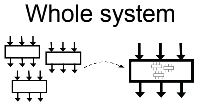
Table A.10 (*continued*)

<table>
<tr><th colspan="2">PLAN</th></tr>
<tr><td>Parameters
</td><td>6.3.3 Consolidate
Consolidation of parameters by models in environmental accounting software:
Energy consumed (chips)
• Combusted wood chips [tonnes] × Energy content wood chips [megawatt-hours per tonne] = Combusted wood chips (energy) [megawatt-hours]
Renewable amount consumed
• Combusted wood chips (energy) [megawatt-hours] × Renewable share - wood chips [#] = Renewable flow - Combusted wood chips [megawatt-hours]
Produced renewable energy (chips)
• Total heat production [megawatt-hours] × Renewable share - wood chips [#] = Heat production from renewable sources [megawatt-hours]
CO_2 emissions from heat production (wood chips)
• Combusted wood chips (energy) [megawatt-hours] × CO_2 factor chips [kilogrammes per megawatt-hour]/1 000 = CO2 [tonnes]
NO_x emissions from heat production (wood chips)
• Combusted wood chips (energy) [megawatt-hours] × NO_x factor chips/pellets [kilogrammes per megawatt-hour]/1 000 = NO_x [tonnes]</td></tr>
<tr><td>System component
</td><td>6.3.4 Synthesize
Data tagged to organization [Levels 1, 2, X, activity, scope (GHG), recipient and source of emission]:
<table><tr><th>Level 3</th><th>Measuring point</th><th>Parameter</th><th>Scope</th><th>Value</th></tr><tr><td>Haraldrud</td><td>Wood chip boiler</td><td>CO_2</td><td>1</td><td>6 121 t</td></tr><tr><td>Haraldrud</td><td>Electric boiler</td><td>CO_2</td><td>2</td><td>6 858 t</td></tr><tr><td>Haraldrud</td><td>Waste boiler</td><td>CO_2</td><td>1</td><td>17 166 t</td></tr></table></td></tr>
<tr><td>Whole system
</td><td>6.3.5 Aggregate
Examples of aggregated use of data:
• Total sum of CO_2 for Hafslund;
• Compare total CO_2 per company;
• Compare CO_2 year by year.</td></tr>
</table>

A.5 Case study: Data sources for quantitative environmental information when performing a life cycle analysis

The example in Table A.11 shows a way to collect and process quantitative environmental information in the construction sector under a whole company point of view.

Table A.11 — Data sources for quantitative environmental information when performing a life cycle analysis

PLAN	
Whole system 	**6.2.1 Conceptualize** A life cycle inventory with local electricity mix as background data.
System component 	**6.2.2 Breakdown** Identify where the different production and transports steps occur in order to identify which electricity mixes to use and how to calculate the electricity mixes.
Parameters 	**6.2.3 Select** Decide on types of electricity production to include in the different mixes and which data categories to include.
Basic data 	**6.2.4 Define** Define precision and credibility requirements.
Measuring methods 	**6.2.5 Identify** Identify and select databases and literature from which to acquire data about electricity production and grid mixes.
DO	
Measuring methods 	**6.3.1 Set up** Acquire data about electricity production and electricity mixes from the selected databases.
Basic data 	**6.3.2 Acquire** Assess fulfilment of precision and credibility requirements of all data.
Parameters 	**6.3.3 Consolidate** Compile data into specific electricity production and electricity mix . Combine data from different sources where necessary.
System component 	**6.3.4 Synthesize** Include the electricity mix unit processes into the life cycle inventory data collection.
Whole system 	**6.3.5 Aggregate** Perform the normalization and the aggregation of the product system and establish its life cycle inventory profile.

A.6 Case study: Data sources for quantitative environmental information in the oil industry — On-shore oil exploration and production (E&P)

The following examples show a way to collect and process quantitative environmental information in the oil industry in the exploration and production (E&P) sector, particularly on-shore operations in two different contexts: a single oilfield (see Table A.12) and an E&P business unit at an oil company (see Table A.13).

Table A.12 — On-shore typical oilfield operation, including oil wells, oil gathering station facility and a water injection system for secondary recovery

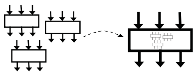
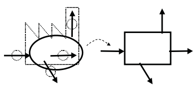
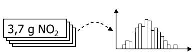
PLAN	
Whole system 	**6.2.1 Conceptualize** Considering the whole system, the typical on-shore oilfield operation for which environmental data is going to be collected in this example includes oil wells, oil gathering station facility and a water injection system for secondary recovery.
System component 	**6.2.2 Breakdown** At this step, we identify the concepts of the selected system which are the main components and which will be analysed later. They can be as detailed as needed. Atmosphere: - Flaring gas emissions; - Fugitive emissions; - Fuel gas emissions; - H_2S emissions. Effluent discharges; Occupation, pollution or loss of soils; Use of natural resources: - Water consumption; - Earth consumption. Waste generation: - Generation of hazardous waste; - Generation of non-hazardous waste; - Generation of municipal waste; Energy use: - Natural gas consumption; - Electric energy consumption.
Parameters 	**6.2.3 Select** The next step is to identify examples of two different system components selected from those mentioned above: • **1. Use of natural resources (water)** In this case, for this system component we could select several parameters, such as: - **Re-use of produced water generated which is separated from the treatment process in used for secondary recovery, avoiding the rising intensity of possible use of fresh water as a supplement (P1);** - Adopting where possible dump-flooding mechanism in order to avoid using fresh water as a supplement and simultaneously reducing the need of energy use to pressuring reservoir in secondary recovery. • **2. Energy use** For this system component we could select different parameters, such as: - **Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation (P2);** - Improve energy efficiency factor of the oil gathering and treatment system; - Promote cogeneration where possible. In this example, P1 and P2 have been selected and a list of parameters related with them and based on environmental good practices can be defined. For this example, these parameters quantify preventive environmental measures implemented on site.

Table A.12 (*continued*)

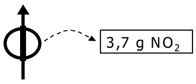
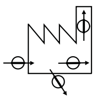
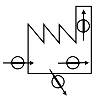
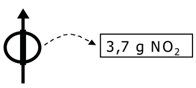
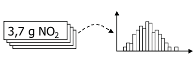
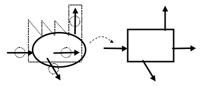
<table>
<tr><th colspan="2">PLAN</th></tr>
<tr><td>Basic data
</td><td>6.2.4 Define
In order to calculate the parameters selected, the data to be managed are:
• For the use of natural resources (water)
Re-use of produced water generated (cubic metres), which is separated from the treatment process in the secondary recovery, avoiding the rising intensity of possible use of fresh water as make up (P1);
• For the energy use
Use of solar energy (renewable) to heat oil during storage and for production well driving automation (P2).</td></tr>
<tr><td>Measuring methods
</td><td>6.2.5 Identify
After clarifying what information needs to be collected, it is time to identify the sources and methods to obtain this data:
• P1: Re-use of produced water generated [cubic metres] which is separated from the treatment process in the secondary recovery
The method to obtain the basic data for this parameter is displayed in flow meter in the input (oil gathering station) and output (water injection for secondary recovery system) and/or estimation using basic sediments and water (BSW) rate where relevant.
Records of flow meters installed in the water injection facilities system, taking into account the type of flow meter installed. Considering two types, cumulative flow meters (displays total amount of water) and instantaneous flow meter (displays the amount of water in each instant)
• P2: Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation
In order to measure the energy supplied, energy meter is used and estimation is made by experts.
- Meter to measure electric energy purchased from energy companies;
- Software and meter for natural gas used in the process of oil water separation, thermo-chemical treater/heater.</td></tr>
<tr><th colspan="2">DO</th></tr>
<tr><td>Measuring methods
</td><td>6.3.1 Set up
• P1: Re-use of produced water generated (cubic metres), which is separated from the treatment process in the secondary recovery
- Installation, calibration and verification of flow meters.
• P2: Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation
- Selection of software and meter calibration procedure for a) natural gas consumption, and b) electric energy consumed.</td></tr>
<tr><td>Basic data
</td><td>6.3.2 Acquire
• P1: Re-use of produced water generated (cubic metres), which is separated from the treatment process in the secondary recovery
- Auto-read flow meters every 30 min (instantaneous flow meter) or daily, weekly, monthly (cumulative flow meter).
• P2: Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation
- Auto read energy meters for 30 min (instantaneous) and daily/monthly (cumulative measurement).</td></tr>
<tr><td>Parameters
</td><td>6.3.3 Consolidate
• P1: Re-use of produced water generated (cubic metres), which is separated from the treatment process in the secondary recovery
- Calculate the percentage of produced water reused for secondary recovery in the process.
• P2: Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation
- Calculate the percentage of energy used in an on-shore oilfield operation.</td></tr>
</table>

Table A.12 (*continued*)

DO

System component



6.3.4 Synthesize

The synthesis of the results can be made, for instance, by assigning two coefficients to each parameter (importance and degree of implementation). We can assign the coefficients based on experts´ suggestions, bibliography, work site experiences, etc. The product of these coefficients gives the score. The total addition of the product of these two numbers in each parameter is the total score for the work site.
For example, we can assign the coefficients 1, 2 or 3 to importance and degree of implementation.

- P1: Characterized by the importance and the degree of implementation, depending on the percentage of produced water generated from the process that is reused in a secondary recovery facility system (>70 %, >85% or >95 %).

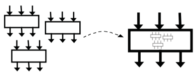
Identification	Importance	Goal (degree of adoption)		
		1	2	3
Re-use of produced water generated (cubic metres), which is separated from the treatment process in the secondary recovery one and avoiding the rising intensity of possible use of fresh water as a supplement (P1)	3	>50 %	>75 %	>95 %

- P2: Characterized by the importance and the degree of implementation, depending on the percentage of electric energy and natural gas replaced for solar energy (>1%, >2% or >3%).

Identification	Importance	Goal (degree of adoption)		
		1	2	3
Use of solar energy (renewable) to heat oil during storage and for production well driving instrumentation (P2)	2	As much as 1 % on total energy used in oilfield	More than 1 % and less than 2 %	More than 2 %

The next step is to calculate the product of the coefficients.

Whole system



6.3.5 Aggregate

Natural resources (water): Percentages, importance, degree of implementation and the result of the product between the importance and the degree of implementation.

Generation of waste: Percentages, importance, degree of implementation and the result of the product between the importance and the degree of implementation.

CHECK

Data accuracy can be ensured by a system of site support visits, internal audits and by the quality checks to which the data are subjected, at the site firstly, and then at the subsequent various stages of data integration.
The technical review of the inventory of environmental data is carried out at the following levels:

- On site: checking lists, measurements, inspections and follow-ups;
- E&P business unit offices: review made in the support site visits;
- Technical services: internal audits; and
- External verifier to the organization: external audits.

If environmental data are gathered at site level, the reviews performed by staff of the E&P business unit offices, technical services and verifiers can be considered external to the site, whereas if the data are processed at corporate level, only the review involving verifiers is external to the organization.

ACT

The results of the different checks and reviews are fed back to the data suppliers on site, aiming to correct and improve the quality of the data and methods used in acquiring and providing the environmental information.

Table A.13 — On-shore E&P business unit

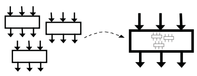
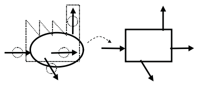
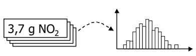
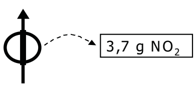
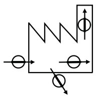
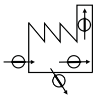
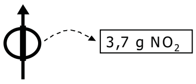
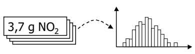
PLAN	
Whole system 	**6.2.1 Conceptualize** At this step, an on-shore E&P business unit is selected as the system that is going to be considered.
System component 	**6.2.2 Breakdown** We identify the main components of the selected system in which the activity of a typical on-shore E&P business unit consists of, may classify and later be analysed. They could, considering the following operations/processes: - Exploration; - Drilling operations - Oil production; - Gas processing and LNG storage; - Oil and natural gas transfer to a refinery/customers. For each of the above, different environmental components can be taken into account, such as atmosphere, use of natural resources, energy use, occupation, pollution or loss of soils, generation of waste, etc. In this case, we are going to choose two of them: drill cutting waste and atmosphere.
Parameters 	**6.2.3 Select** The next step is to identify examples of two different system components selected from the above mentioned. Once a) drilling operations and b) oil production, treatment and storage are selected for this example, the following can be considered: • 1. Drill cutting waste generation - could select for this system (a) one of the following parameters: **Use as much as possible drilling fluid water based to make possible re-use of waste as raw material in construction sector, road pavement, etc. (P3);** - Store drill cutting waste in rubber lined soil base; - Make research in order to make diversify its re-use. • 2. Atmosphere (contribution to climate change) For this system component (b) we could select one of the following parameters: - Forestation of areas where the activities is carried on; - **Manage to reduce flaring of production associated gas (P4).** In this example, P3 and P4 have been selected and a list of parameters related with them and based on environmental good practices can be defined. These parameters quantify preventive environmental measures implemented on site. The parameters can be evaluated on the basis of two coefficients: the importance of the good practice and its degree of implementation. The product of these coefficients yields a score that can be considered a value of the site's environmental performance. The data needed to obtain the final indexes may be, at first, mostly estimates falling within a reasonable range, provided by technical staff in charge of the acquisition of environmental data or by experts' opinion. During the site life, these estimates are permanently verified, checked and adjusted.
Basic data 	**6.2.4 Define** In order to calculate the parameters selected for drilling operations for the on-shore E&P business unit, the data to be managed come from each well drilled site according to drilling rig records. • **Drill cutting waste** (tonnes of drilling waste for each possible destiny: landfill, recycling on site, etc.) - Use where possible drilling fluid water based to make possible an easier way of re-using waste as raw material in construction sector, road pavement etc., (P3); - Number of wells where possible to use drilling fluid water based, describing depth and other characteristics that drive the choice and waste volume. • **Atmosphere (climate change)** (Rate of associated gas that is not flared in the oilfield production processes, as a percentage) - Manage to reduce flaring of production associated gas (P4). Each process/facility that can imply in gas flaring, analysing occurrence records of flaring throughout a defined period is necessary.

Table A.13 (*continued*)

PLAN	
Measuring methods 	**6.2.5 Identify** **Use where possible drilling fluid water based to make possible an easier way of re-using waste as raw material in construction sector, road pavement etc., (P3)** In the work site (drilling rig), a report with the information about the drilling fluid can be used, depth of the drilled well, records of transportation and destiny/use. - Surveys filled out by the work site manager or by experts (measurements or estimations). **Manage to reduce flaring of production associated gas (P4)** The main points where flaring of associated gas takes place should be known, making changing in procedure and technology to make feasible avoid flaring improving safety condition and at same time. Experts in processes and automation could make surveys aided by employees working on each site (for procedures) - Surveys filled out by the work site manager or by experts (measurements or estimations).
DO	
Measuring methods 	**6.3.1 Set up** • P3: Use where possible drilling fluid water based to make possible an easier way of re-using waste as raw material in construction sector, road pavement, etc. - Programme surveys software and check the computers and the server for receiving the surveys. • P4: Manage to reduce flaring of production associated gas - Programme surveys software and check the computers and the server for receiving the surveys.
Basic data 	**6.3.2 Acquire** • P3: Use where possible drilling fluid water based to make possible an easier way of re-using waste as raw material in construction sector, road pavement, etc. - Fill out the survey every three months • P4: Manage to reduce flaring of production associated gas - Fill out the survey every month
Parameters 	**6.3.3 Consolidate** • P3: Use where possible drilling fluid water based to make possible an easier way of re-using waste as raw material in construction sector, road pavement, etc. - Calculate the total of drilling cut waste generated in the whole process of drilling operations and calculate the number of delivery for each use/destiny; • P4: Manage to reduce flaring of production associated gas - Gather information about areas/facilities, where associated production gas flaring occurs and the relevant amount.

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1) Under preparation.

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