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KEY FEATURES OF DOMESTIC MONITORING SYSTEMS UNDER THE KYOTO PROTOCOL

INFORMATION PAPER

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FOREWORD

The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. As such, the papers do not necessarily represent the views of the OECD, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group.

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Executive summary

Implementing the Kyoto Protocol will require Annex I Parties to set up different kinds of domestic monitoring systems. At least four types of monitoring systems can be envisaged, either as distinct or as integrated systems:

National inventory systems monitor greenhouse gas emissions (and removals) at national level.

Entity-level emissions monitoring systems and **project-level emissions monitoring systems** provide a framework for entities to monitor and report greenhouse gas emissions (or removals) resulting from their activities or from specific projects, such as joint implementation projects.

Assigned amount tracking systems –or national registry systems- track changes in a Party's assigned amount. A Party's assigned amount may change pursuant to various provisions of the Protocol and, in particular, to the use of the flexibility mechanisms established under the Protocol.

In the context of the Kyoto Protocol, these systems can serve many different purposes, whether at international or at national level.

At the **international level**, national inventory and assigned amount tracking systems will be needed to allow assessment of compliance with the Kyoto targets. Project-level emissions monitoring systems may also be needed for compliance under the Kyoto Protocol, in case of joint implementation projects. Entity-level emissions monitoring systems are not needed to assess compliance with the Kyoto Protocol. However, they are a critical element of domestic mitigation strategies and can also help to enhance the quality of inventory data.

At the **domestic level**, these different monitoring systems will help Parties meet the Kyoto targets (Art. 3 under the Protocol). National inventory systems, together with assigned amount tracking systems, will allow a Party to assess whether it is on track to meet these commitments. National inventory systems can also identify which emission sources should be prioritised for domestic action. Entity-level and/or project-level emission monitoring can be part of a domestic compliance system established to assess whether entities comply with their legal requirements and/or voluntary commitments to reduce emissions (or enhance removals). If entities are allowed to trade portions of assigned amounts, assigned amount tracking would also be needed at entity level to assess whether these entities comply with their legal requirements.

Objective of the paper

In view of the central role that monitoring plays in implementing the Kyoto Protocol, a key concern that arises is the one of data quality, particularly when monitoring systems are used for compliance purposes. Ideally, this case requires the best quality standard. In practice, even in a compliance context, errors, uncertainties, omissions, inconsistencies or lack of transparency may never be completely eliminated, but should be minimised as much as possible (IPCC 1998a).

The main objective of this paper is to identify key functions, processes and/or institutions to ensure high data quality. The paper also considers to what extent specific guidance can be defined for each of these key features of domestic monitoring systems. Drawing on current efforts to elaborate guidance for each of these systems at national and/or international level, the paper identifies features of monitoring systems that might need further consideration.

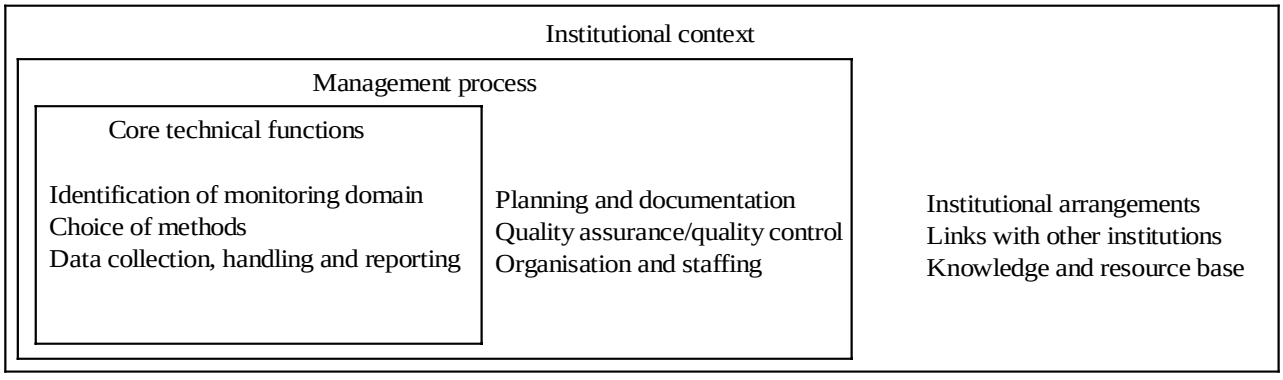
This paper provides general (background) information on monitoring systems. It does not prejudge the need for international guidelines on each of the systems considered. Indeed, international guidelines under the Kyoto Protocol are only foreseen for monitoring systems that are needed for compliance assessment under this Protocol. However, sound development of all types of domestic monitoring systems considered in this paper will reinforce the Kyoto Protocol credibility, in helping build confidence that Parties are implementing their commitments under the Kyoto Protocol.

Other approaches (than internationally agreed guidelines) might underpin the development of these monitoring systems. In some cases, assistance for capacity building may prove a better way to ensure a continuous process of data quality improvement. If Parties wish so, consideration of these monitoring systems might also become part of the national communication review function. This step could build understanding among Parties about the efforts being made by national governments to implement the Kyoto Protocol commitments. It could also raise awareness among Parties about the importance of the domestic monitoring function, facilitate the sharing of information on good practice and help to identify where individual Parties may need assistance. This paper might therefore be useful to identify priorities for capacity building programmes or for the international review process.

Domestic systems: an analytical framework

The paper mainly draws on current efforts to define good practice standards at national and/or international level. The IPCC has developed recommendations for good practice guidance for national inventories (IPCC 2000). In the case of entity and/or project-level emissions monitoring, there are a certain number of initiatives by private companies, non-governmental organisations and governments to develop guidance for such systems at national and international level. As for assigned amount tracking, no domestic system has yet been established for greenhouse gases. However, a standard might emerge internationally, possibly based on proposals made by some Parties in the framework of current negotiations.

Although these different initiatives vary in scope and purpose, the paper uses a common analytical framework for all types of monitoring systems, emphasising similarities and differences between them. This framework identifies three distinct levels of analysis, a technical level, a managerial level and an institutional level.



Sound development of the different monitoring systems at these three levels is needed to ensure sufficient data quality. Basic technical functions, in particular the choice of monitoring methods, set the overall level of quality monitoring systems can aim for. An efficient management process minimises the risk of errors and inconsistencies in performing these basic technical functions. A strong institutional framework makes it possible to improve the quality of monitoring activities and to set up an efficient management process.

The development of these different features raises common, but also different, sets of issues for each of the monitoring systems considered in this paper.

Core technical functions

The choice of methods is the main concern for national inventory systems. For each greenhouse gas and each source/sink category, there is likely to be a range of possible methods from the most detailed (e.g. frequent field measurements) to more or aggregate estimation techniques. Measurement based and other data intensive methods are considered to be the most accurate, but also the most resource intensive. It may not be useful or feasible to prescribe the use of specific methods for each emissions source as it could limit the continuous development of methods that best suit specific circumstances in a particular country or entity/project. One option is to identify "key sources" in each country for which more complex methods might be required. The IPCC has provided the tools for Parties to define which are these key sources.

The same methodological issue might arise with entity/project-level emissions monitoring systems, unless their monitoring domain is restricted to those emissions sources that can be estimated with relatively simple methods. Defining the boundaries of the monitoring domain for this type of monitoring systems is also likely to be a critical issue for entities, since it may be linked to specific emission reduction programmes.

As regards assigned amount tracking systems, the choice of methods is not really an issue, since there is only one possible method for tracking changes in assigned amount. A clear identification of the monitoring domain, timeliness (in processing trades) and compatibility between systems seem to be the most relevant issues in setting up such systems. Electronic data processing, much like on-line banking systems, would make monitoring much easier. More generally, electronic data collection, handling and reporting would benefit the development of all types of monitoring systems.

The management process

The general characteristics of an efficient management process are common to all monitoring systems discussed in this paper. Pertinent standards and guidelines already exist at international level and apply to all data quality management systems. They should be supplemented by procedures that are adapted to the specific characteristics of emissions monitoring and assigned amount tracking systems. These procedures might be more or less resource intensive.

The IPCC has also provided "good practice" guidance on quality assurance/quality control and documentation for national inventories. It has identified different tiers for QA/QC, with increasing levels of complexity. This effort might also be useful for developing entity/project-level emissions monitoring systems. A similar exercise could be undertaken for assigned amount tracking systems.

Developing an efficient management system may be quite costly, in particular when new systems need to be set up, or when new methods need to be used. However, it helps reduce the burden of data quality assessment and review by end users of data, which might in turn save resources.

The institutional context

The different institutional features of monitoring systems are very country-specific. However, a number of issues might pertain to most institutional frameworks within which monitoring systems operate. The main issues identified in this paper are common to all types of monitoring systems:

– Are there institutional arrangements that establish monitoring systems? Is responsibility clearly defined? Is the support from higher management sufficient? Are there formal arrangements, or even

legal authority, for collecting and verifying data from different sources? Is monitoring part of a domestic compliance and enforcement system (in particular, for entity/project-level monitoring systems)?

- Which are the institutions that collaborate in the monitoring process? What are the strengths and weaknesses of these institutions?

- What are the strengths and weaknesses in the country in terms of expertise needed to set up monitoring systems? Are there many forms of co-operation between government, industry and research institutions to exchange information on monitoring activities?

Guidance might be defined for some of these key institutional features. At a minimum, Parties might want to require that the responsible institution(s), as well as institutions that collaborate in the monitoring process, be clearly identified. Other options for guidance might be requirements that monitoring systems have a clear and permanent status within the institutional structure, be reviewed by independent third parties and that they have legal authority to collect necessary data.

An assessment of the strengths and weaknesses of institutions might also provide insights into the specific capabilities of each Annex I Party in achieving good practice in their monitoring systems.

A possible way forward

The table below presents an indicative list of key elements of domestic monitoring systems for which guidance could be developed at national and/or international level. These are generic characteristics that cut across differences between monitoring systems. Priorities for the further development of each system may differ, depending on what has already been achieved, at national and/or international level.

For **national inventory systems**, the IPCC good practice work covers a wide range of relevant issues. It is mainly concerned with providing guidance on methodological choice, uncertainty assessment, quality assurance/quality control and reporting and documentation. The IPCC provides tools to select methods and procedures. However, it is up to Parties to the Convention (UNFCCC) to define minimum requirements for these different elements. Difficult political choices may need to be made on how to use IPCC good practice work. As regards other management functions, like planning, organisation and staffing, and institutions, more analytical work may be needed to further develop what guidance might look like on these issues. In view of the specific circumstances of each country, it may be that guidance can only be very general on these matters.

There exist some (non-governmental and governmental) initiatives at this stage to develop guidance for **entity/project-level emissions monitoring systems**. Common approaches might facilitate the development of the Kyoto Mechanisms. For entity-level monitoring, it is unlikely this would be in the UNFCCC framework, since it is not required under the Kyoto Protocol. The IPCC good practice guidance is also relevant for entity-level monitoring and may provide some insights into project-level monitoring systems as well.

Assigned amount tracking systems are the least developed of all systems, but also probably the simplest to develop and implement. Current proposals focus on a clear identification of the monitoring domain, reporting and public accessibility. Further elaboration of registry systems might focus on the data acquisition and handling process, in particular on how systems in different countries link up as well as on timeliness of data processing. Management and institutional issues may also be discussed, although they may not be as critically important for these systems as they are for national inventory systems.

Table 1: **Indicative list of key elements of domestic monitoring systems**

Core technical functions	
Identification of monitoring domain	*Identification of geographical and temporal boundaries, domain categories or subdivisions, units of measurement*
Choice of monitoring methods	*Procedures to identify appropriate methods for source categories (for emissions monitoring)*
Data collection, handling and reporting	*Standardised procedures/formats for data collection, handling and reporting, electronic data submittal and handling* *Indication of measurement process/frequency, number/representativeness of sources (for emissions monitoring)* *Reporting on key data*
The management process	
Planning and documentation	*Definition of data quality objectives (possibly in quantitative terms), elaboration of a work plan or monitoring protocols, identification of organisational structure, staffing and responsibilities, record of actual monitoring activities, report of the monitoring results and assessment of its quality, public accessibility*
Quality assurance/ quality control	*Procedures to select QA/QC methods (i.e. data comparison, sample calculations, uncertainty assessment, sensitivity analysis, peer review, audits)*
Organisation and staffing	*Identification of lead person responsible and other levels of responsibility (e.g. QA co-ordinator), staff size and technical competence*
The institutional context	
Institutional arrangements	*Identification of lead institution(s) responsible and other levels of responsibility (e.g. specialised agencies), relationships between monitoring systems, existence/permanence of legal arrangements, support from higher management/political authorities, legal authority to collect data, domestic verification process, enforcement powers, involvement of regulatory authorities*
Collaboration with other institutions	*Identification of organisations (statistical system, entities, environmental organisations, audit firms) collaborating in the process; third party review/audit*
Knowledge base	*Situation of government, business and research community ; existence of networks and training programmes*

1 Introduction

1.1 Objective and approach

Implementing the Kyoto Protocol will require Annex I Parties to set up different kinds of domestic monitoring systems. At least four types of monitoring systems can be envisaged, either as distinct or integrated systems:

- **National inventory systems** monitor greenhouse gas emissions (and removals) at national level.

- **Entity-level emissions monitoring systems** and **project-level emissions monitoring systems** provide a framework for entities to monitor and report greenhouse gas emissions (or removals) resulting from their activities or from specific projects, such as joint implementation projects.

- **Assigned amount tracking systems** (or national registry systems) track changes in a Party's assigned amount. A Party's assigned amount may change pursuant to various provisions of the Protocol and, in particular, to the use of the flexibility mechanisms established under the Protocol.

In the context of the Kyoto Protocol, these systems can serve many different purposes, whether at international or at national level. In view of the central role that monitoring plays in implementing the Kyoto Protocol, a key concern that arises is the one of data quality, particularly when monitoring systems are used for compliance purposes. Ideally, this case requires the best quality standard. In practice, even in a compliance context, errors, uncertainties, omissions, inconsistencies or lack of transparency may never be completely eliminated, but should be minimised as much as possible (IPCC 1998a).

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Although these different initiatives vary in scope and purpose, the paper uses a common analytical framework for all types of monitoring systems, emphasising similarities and differences between them. This framework identifies three distinct levels of analysis, a technical level, a managerial level and an institutional level.

1.2 Structure of the paper

Section 2 of the study presents the domestic monitoring systems that could emerge from Parties' efforts to implement the Kyoto Protocol as well as the domestic and/or international compliance context in which they are likely to be used. This section also presents an analytical framework for identifying the key features of monitoring systems and discussing the key issues that they raise in the context of compliance.

Sections 3, 4 and 5 of this paper discuss the characteristics of monitoring systems that may be relevant in a compliance context. Section 3 discusses the core technical functions of domestic systems. Section 4 discusses key features of the management process. Section 5 discusses the institutional context of monitoring systems.

Section 6 presents the key conclusions.

1.3 Terminology

For the purpose of this paper, the main terms that are used throughout the study are defined as such:

- *Monitoring*. Monitoring is the generic term used throughout for the collection and handling of data on greenhouse gas emissions (and removals) and/or changes in assigned amounts.

- *Tracking.* Tracking is considered as a synonym of monitoring and is used more specifically for the monitoring of assigned amounts.

- *Entity*. Entities are defined as companies or other organisations that emit greenhouse gases in the course of their activities and/or undertake emissions reduction projects.

- *Assigned amount*. An assigned amount is defined as a greenhouse gas emission level that each Annex I Party shall not exceed during a (five-year) commitment period.

- *Assigned amount unit*. A standard quantity of assigned amount that could be used by Annex I Parties, if so decided, to transfer and/or acquire emissions reduction units under Art. 6, certified emissions reductions under Art. 12, or parts of assigned amounts under Art. 17.

2. Domestic monitoring systems under the Kyoto Protocol

2.1 Main roles of domestic systems under the Kyoto Protocol

Monitoring serves many different purposes in environmental policy. It can be used for public information purposes (e.g. on general emission trends for an entity or a nation), general assessment or research (e.g. on alternative control or mitigation methods), policy making or standard setting (e.g. to identify specific mitigation measures), enforcement and compliance purposes.

In the context of climate change, monitoring has so far been used primarily for public information, general assessment and policy-making purposes. The Kyoto Protocol places a new emphasis on monitoring. It will be needed, not just for information, assessment or policy making purposes, but to assess compliance with international and possibly also domestic obligations.

In the context of the Kyoto Protocol, different types of monitoring systems could be set up by Annex I Parties: national inventory systems, entity-level emissions monitoring systems, project-level emissions monitoring systems, assigned amount tracking systems (or registry systems). These monitoring systems may be used for different purposes, whether at national or international level. Table 2 summarises the main roles of these monitoring systems. These roles are discussed in the rest of this section.

Table 2: **Roles of domestic monitoring systems at international and national level**

	National inventory systems	**Entity-level emissions monitoring systems**	**Project-level emission monitoring systems**	**Assigned amount tracking systems**
Information/ assessment	National/ International	National/ International	National/ International	National/ International
Policy making	National	National	National	National
Compliance	International	National	National/ International	National/ International

Parties may choose to set four distinct monitoring systems, or, alternatively, integrate them into a single monitoring system, as they are closely interrelated. For the purpose of this paper, these systems are discussed separately, except for entity and project-level monitoring systems, which are grouped together.

2.1.1 National inventory systems

National inventories, required under the Climate Change Convention, have so far been used primarily:

- at international level, for general assessment of emissions sources, levels and trends and as a basis for defining quantitative commitments;

- at national level, for public information purposes, for general assessment of emissions sources, levels and trends and as a basis for identifying mitigation measures.

National inventories are also required under the Kyoto Protocol. The Kyoto Protocol states that "[e]ach Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol" and that "guidelines for such national systems […] shall be decided by the Conference of the Parties serving as the meeting of the Parties"(Art. 5.1.).

These national systems are the only monitoring systems that are explicitly required under the Protocol. The importance of these systems is justified in that they will be the main sources of data to assess compliance with quantitative emissions limitation or reduction commitments under KP Art.3. Indeed, the main data that will be needed to assess a Party's compliance with Art. 3 commitments will be its base year inventory, which serves as a basis for defining assigned amounts, as well as its inventories for the years 2008-2012.

Annex I Parties may also need to comply with Art. 5 in order to participate in the Kyoto Mechanisms[1]. This means that setting up a national system according to the guidelines to be defined under Art. 5.1 may become an eligibility requirement to transfer and/or acquire assigned amount units under Art. 6, 12 and/or 17. Indeed, a Party's level of emissions during the commitment period will determine what is legitimately available to trade, hence the importance of national inventories and systems to ensure their preparation in the context of the mechanisms. The requirement in Article 5 for countries to have a national system in place may improve the reliability or overall quality of inventory data and thus improve the compliance assessment process under the Protocol.

In the context of the Kyoto Protocol, national inventories will also continue to serve domestic purposes. In particular, they will continue to be used to identify the main sources (and sinks) of greenhouse gases as a way to define priorities for domestic climate policy against the backdrop of international obligations.

2.1.2 Entity-level and/or project-level emissions monitoring systems

In addition to national inventory systems that are required under the Protocol, Parties may want to set up intrinsically more detailed emissions monitoring frameworks to monitor entity-level and/or project-level emissions and removals. Entities would themselves monitor emissions and removals of greenhouse gases resulting from their activities and report them under these monitoring systems.

Such systems may be used for two main purposes. These systems may complement a Party's national inventory system by helping to estimate more precisely emissions from certain sources (or removals by certain sinks). They can also be used as part of a domestic programme or policy that is put in place by a government to limit or reduce (net) emissions.

The role of entity/project-level monitoring systems in complementing national inventory systems might become increasingly important, as Parties wish to improve the quality of their national inventory data. For many estimation methods, entity monitoring is indeed preferred, provided resources are available (see Section 3.2)[2]. However, care needs to be taken in ensuring its quality and in integrating entity monitoring with national estimates[3].

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1 It is already an eligibility requirement for Parties wishing to acquire emission reduction credits under Art. 6 and has been suggested by Annex I Parties as an eligibility requirement for participation in emission trading under Art. 17.

2 Differences between entity-level and national (aggregate) inventory data might emerge, for instance, if emission reductions are recorded at entity level, but not at national level. This may happen if national inventory systems use aggregate activity data as well as aggregate emissions factors that are not updated

In addition to their use in the context of national inventories, entity and/or project-level monitoring may be used as part of domestic emissions reduction programmes (see Box 1). Different kinds of domestic programmes could require entity-level or project-level emissions monitoring. These programmes could be either voluntary or mandatory, be entity-based or project-based, involve or not trading activities, be coupled or not with the Kyoto Mechanisms.

Box 1: **Types of domestic programmes**

Entity-based voluntary programmes. Entities may agree to voluntarily reduce emissions resulting from their activities against a baseline; or, alternatively, they might agree not to exceed a certain level of emissions. There are many reasons why entities would want to do so, even in the absence of a domestic trading system. They may want to do so for public recognition, as pilot programmes to gain experience in reducing emissions, or to avoid more stringent, regulatory measures. They may also want to do so in order to gain emissions reductions credits that could be banked and/or traded at a later stage (credit for early action).

Project-based voluntary programmes. For the same reasons cited above, entities may want to voluntarily reduce emissions in the framework of specific emissions reduction projects, involving a subset of their own activities or other entities.

Entity-based mandatory programmes. Parties may set up a regulatory framework whereby a particular subset of entities are required to hold their emission level below an agreed baseline or a certain level of allowed emissions.

Domestic trading systems. Any of the programmes above could be combined with a trading system: entities could trade either emissions reductions below the baseline (credit trading) or their allowed emissions (allowance trading). Domestic trading programmes may emerge in the coming years as countries prepare to implement policies to achieve the Kyoto targets.

Kyoto Mechanisms. These programmes can be coupled with the Kyoto mechanisms, if entities are authorised to trade internationally:

- credits or allowances could be transferred through the international emissions trading system to be set up under KP Art.17 as parts of assigned amounts (PAAs).

- credits could be earned through projects implemented jointly with other (foreign) entities and transferred under KP Art. 6 as emissions reductions units (ERUs).

While these programmes may differ in many aspects, they all require emissions monitoring and reporting at entity level and/or project level. This monitoring system is a key element of these voluntary or regulatory programmes to ensure that entities comply with their voluntary commitments or regulatory requirements and that real emission reductions are achieved. It will therefore help build confidence that a

frequently enough (see section 3.3.2). Inversely, it might be that national inventory systems overestimate emissions reductions resulting from domestic programmes and policies, while this is not reflected in entity-level monitoring.

[3] Entity monitoring is usually only practical for large point sources. Particular attention should therefore be given to situations of "partial coverage", whereby entity-level emissions cover only a part of a source category within the national inventory.

Party will meet its quantitative commitments under the Kyoto Protocol. If entities are authorised to trade internationally through international emissions trading or joint implementation, entity/project-level emissions monitoring systems can also be an essential part of domestic action to reduce the risk of overselling portions of a Party's assigned amount.

Entity and project-level emissions monitoring systems are therefore likely to play an important role in enhancing the overall environmental credibility of the Protocol. However, they are likely to be required only in a domestic compliance framework. At international level, Parties have so far only proposed project-level emissions monitoring and/or reporting as a requirement under Art. 6 of the Kyoto Protocol (joint implementation).

2.1.3 Assigned amount tracking systems

The Kyoto Protocol allows changes in an Annex I Party's assigned amount under certain circumstances:

- Art. 3.3 requires Annex I Parties to use net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, to meet their quantified emission reduction and limitation commitments under Art. 3, thereby adding these net changes to, or substracting them from, their assigned amount.

- Art. 3.4. allows Annex I Parties to add to, or substract from, their assigned amounts net changes in greenhouse gas emissions by sources and removals by sinks resulting from additional human-induced activities in agricultural soils and land-use change and forestry categories, if a decision is taken at the Meeting of the Parties. This would become a requirement for the second and subsequent commitment periods.

- Art. 3.10 requires Annex I Parties to add to their assigned amount any emission reduction units acquired under Art. 6 (joint implementation) or any parts of assigned amount acquired under Art. 17 (emissions trading).

- Art. 3.11 requires Annex I Parties to substract to their assigned amount any emission reduction units transferred under Art .6 or parts of assigned amount transferred under Art. 17.

- Art. 3.12 requires Annex I Parties to add to their assigned amount any certified emission reductions acquired under Art. 12 (clean development mechanism).

- Art. 3.13 allows Annex I Parties, if their emissions in a commitment period is less than its assigned amount to add this difference to their assigned amount for subsequent commitment periods (banking).

- Art. 3.1. allows Annex I Parties to meet their commitments jointly. Under Art. 4, those Parties can allocate among themselves their combined assigned amounts as defined in the Protocol and notify their respective emission levels to the Climate Change secretariat on the date of ratification[4].

[4] Since such Parties decide to combine their assigned amounts and notify "new" emission levels at the time of ratification, there may be a legal issue as to whether these emission levels are effectively changes in original assigned amounts, new assigned amounts, or yet another legal definition. This paper assumes that assigned amount tracking systems could be used for the provisions under Art. 4, only if Parties were to decide that they effectively represent changes in assigned amounts.

– Parties might want to set up a single national system to record all such changes in a transparent manner in order to report them to the Conference of the Parties (serving as the meeting of the Parties to the Protocol), as it is likely to be required under Art. 7. 1. Assigned amount tracking (or registry) systems would need to take into account the modalities for the accounting of assigned amounts, to be decided by the Conference of the Parties serving as the meeting of the Parties prior to the first commitment period, according to Art. 7.4. Specific guidelines on registries might also be developed under Art. 6 and 17 (joint implementation and international emissions trading).

This system could also be used domestically should Parties establish domestic trading programmes. These programmes might devolve units of assigned amount to entities and allow them to bank and/or transfer those units. Information on assigned amount units held by each of these entities could be recorded in the tracking system as well as their domestic and international transactions.

In a system where changes in assigned amounts occur, this tracking system is essential to assess compliance, domestically and/or internationally, together with emissions monitoring systems.

In the international context, both national inventory systems and assigned amount tracking systems are needed to assess compliance. Being in compliance means holding enough assigned amount units at the end of a commitment period to offset emissions that occurred during this period. For the first commitment period, national inventories for the years 2008-2012 are compared with the level of assigned amounts that each Party holds at the end of this period.

In the national context, being in compliance might have a different meaning according to the domestic programme that has been established:

– in the case of an allowance trading programme, entities would be required to hold enough assigned amount units (as recorded in the national registry system) at the end of the commitment period that is defined in the domestic programme to offset their emissions that occurred during that period, as reported under the emissions monitoring system.

– in the case of a credit trading or joint implementation programme, credits are devolved to entities as assigned amount units when it is shown that they reduce their emissions below an agreed baseline. This is done by comparing their actual emission levels, as reported under the emissions monitoring system, with their agreed baseline. These credits can be held as assigned amount units, acquired and/or transferred through the assigned amount tracking system.

2.2 Data quality in a compliance context

In the compliance system identified in the preceding section, compliance assessment rests entirely on the quality of emissions and assigned amount data. However, there are only a few cases where data on the (absolute) level of emissions (and on assigned amounts or allowances) have been used to assess compliance, whether at national or international level.

2.2.1 The quality issue

At the international level, a few environmental agreements require Parties to report national emissions data in order to assess compliance, but the data quality is often unknown (Victor et al. 1998; OECD 1999b). In the climate change context, it is recognised the current level of uncertainties in national inventories may be higher than desirable to assess compliance in the Protocol context. Uncertainties in emissions trends are likely to be lower than uncertainties in any single year. However, they may be high enough, so that “unless

uncertainties are reduced and managed, there is a risk that Parties could adjust their emissions estimates within the band of uncertainty to help them "meet" their commitments, introducing bias in the emission estimates" (IPCC 1999).

At the domestic level, there is little experience of domestic programmes that rely on greenhouse gas emissions data to assess compliance in a regulatory sense. In most Annex I Parties, domestic regulatory requirements usually refer to the achievement of specific threshold emissions rates (per unit of activity), but not absolute emissions. Meeting these thresholds is usually done by using best available control technologies. Relying on emissions data to assess compliance is therefore somewhat revolutionary, even in a domestic context[5]. It may simplify regulatory requirements, but requires high quality emissions monitoring systems (Kruger et al. 1999).

In the case of assigned amount tracking systems, the quality issue is somewhat different. No uncertainties are associated with accounting for changes in assigned amounts. However, these systems are not error-free and will most likely need to handle vast amounts of data. This also raises quality issues comparable to the ones that can be raised with emissions monitoring.

2.2.2 Quality criteria and standards

Quality cannot be defined in a simple manner. There are different quality criteria that can be identified. The criteria used in this paper for quality assessment are the following[6]:

- *Transparency*. The monitoring process, including methods and technologies used, is properly documented, in particular to allow for review, prior to compliance assessment.

- *Comparability/compatibility*. Methods, technologies and reporting formats are comparable or compatible with those used in other similar data sets (e.g. across and/or within countries).

- *Consistency*. Methods, technologies and reporting formats are consistent over the years.

- *Completeness*. The data cover the entire monitoring domain.

- *Accuracy/confidence*. The data are correct, reliable or (relatively) exact.

- *Timeliness*. Data is monitored and reported in a timely manner. If reporting deadlines are prescribed, they are respected.

- *Efficiency*. The monitoring process ensures the best possible quality within the available resources.

The relevance of each criterion depends upon the purpose of monitoring. For informational purposes, consistency (over time) and comparability (with similar data sets) might be the most important criteria. In the context of compliance, all criteria become important. Transparency becomes essential to facilitate the review process that is needed to assess compliance. Accuracy, together with consistency and completeness, is particularly needed in order to assess compliance with a sufficient degree of certainty. In a legal context, timeliness also becomes a key criterion.

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5 For instance, the SO_2 allowance trading programme is the first air pollution programme in the US that relies entirely on emissions monitoring to assess compliance (Kruger et al. 1999).

6 Adapted from FCCC 1999b. Definitions have a higher order of generality to accommodate the characteristics of the different monitoring systems discussed in this paper.

Ideally, the best quality standard should be required for compliance purposes. In practice, even in a compliance context, quality criteria may only be met with varying degrees of success. Errors, uncertainties, omissions, inconsistencies or lack of transparency may never be completely eliminated, but should be minimised as much as possible (IPCC 1998a). The acceptable level of errors or uncertainties may be different for each type of monitoring system. Systems that monitor emissions related to direct health impacts may require a higher level of data quality than those that monitor long term environmental problems, such as climate change. The quality level that is acceptable also depends on what can be achieved with a reasonable level of resources.

Even if the highest quality cannot be reached, certain (minimum) quality standards are needed in a compliance context. There are not yet clearly identified quality standards for monitoring systems in a climate change context.

For national inventory systems, the IPCC 1996 Revised Guidelines, referred to hereafter as the *IPCC guidelines*, define minimum international requirements for preparing national inventories. However, the reporting instructions are the only mandatory part of the guidelines (OECD 1999b). To supplement these guidelines, the IPCC has identified good practice guidance for the preparation of national inventories, with a view to minimise errors and uncertainties with a view of its inclusion in the guidelines for national inventory systems to be adopted by the COP under KP Art. 5.1 (IPCC 2000)[7].

In the case of entity and/or project-level GHG emissions monitoring, there are currently very few established systems in Annex I Parties that monitor greenhouse gas emissions (and removals). There are, however, other initiatives by private companies and governments to set up pilot or voluntary monitoring systems. This may lead progressively to the definition of good practice guidance at national and/or international level[8].

As for assigned amount tracking, no domestic system has yet been established in the climate change context. However, some countries have proposed guidelines on national registries in the framework of current negotiations under the UNFCCC[9]. Some standard might emerge internationally, once a decision is made to set up such systems. A standard approach would encourage consistency and allow these systems to link up in order to facilitate international transfers of assigned amount units (New Zealand 1999).

2.3 Key features of monitoring systems

This paper does not attempt to provide guidance for any of these monitoring systems, but rather to identify the features of monitoring systems that are relevant in the process of developing guidance, whether at national or international level. In this paper, the key features of monitoring systems are discussed at three different analytical levels:

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7 References to good practice have already been incorporated in the Revised UNFCCC guidelines on annual inventories, referred to hereafter as the UNFCCC guidelines (UNFCCC 1999b).

8 Different countries have set up voluntary of mandatory reporting programmes for greenhouse gases (US, UK, Canada, Germany, NL). Some companies, such as BP Amoco, have also set up voluntary monitoring programmes. In addition, guidelines have been set in different countries on monitoring performance of individual projects. There are also international initiatives to build an internationally accepted monitoring protocol (see WRI/WBCSD 1999). International guidance is also being developed for monitoring emissions from projects under the CDM (KP Art. 12). This guidance could apply to joint implementation programmes in Annex I Parties (KP Art. 6).

9 See USEPA (1999); New Zealand (1999)

- the **technical level** refers to the core technical functions of a monitoring system: identification of the monitoring domain, choice of methods, data collection, handling and reporting;

- the **managerial level** refers to the larger set of functions that are needed in the process of managing monitoring systems, in addition to the technical functions identified above: planning and documentation, quality assurance/quality control as well as organisation and staffing;

- the **institutional level** refers to the broad institutional context of monitoring systems: the institutional arrangements that establish these systems, their links to other institutions, as well as the overall knowledge and resource base of a country.

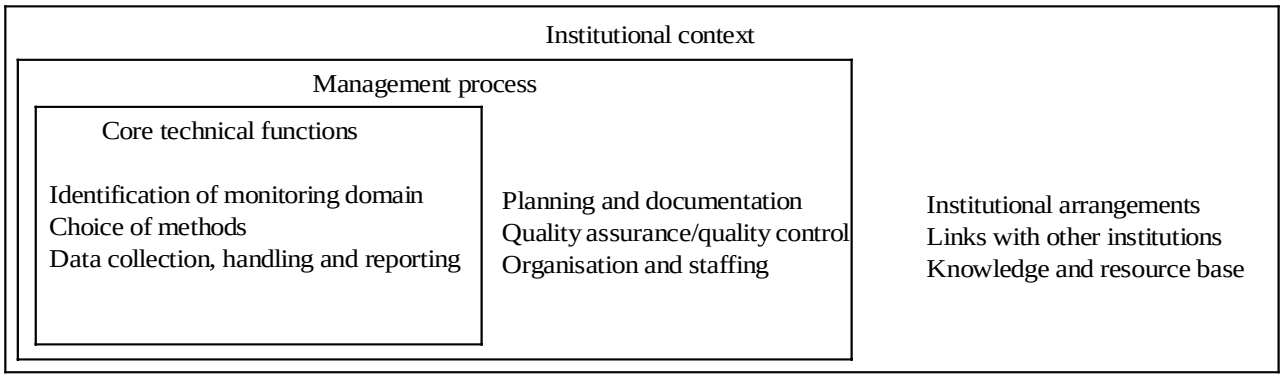
Quality can be assessed at any of the three levels identified above, but it is important to recognise that these levels are interrelated.

- The most direct way to assess quality may be to assess how core technical functions are performed, in particular which methods are used. However, these functions are part of the management process. If management is inefficient, even the best methods (and technologies) may not be used properly.

- The management process can ensure that the risk of errors in using such methods and technologies is minimised. However, good management practices can only produce results as good as the methods that are used (EIIP 1996/1997).

- Weak institutions, inefficient statistical systems, lack of expertise or financial resources in the country can hinder any improvement at technical or managerial level.

Figure 1: **Monitoring systems: a conceptual framework**



3. Core technical functions

This section provides a general discussion of issues regarding the core technical functions of domestic systems. It draws mainly on IPCC work on good practice, on existing experience on entity/project-level monitoring, such as the US SO_2 trading programme, the BP Amoco monitoring project and the ILUMEX project and on current proposals regarding assigned amount tracking systems (New Zealand 1999; USEPA 1999).

3.1 Identification of the monitoring domain

Identifying *which data should be monitored*, in other words, what is the scope of the monitoring activity is a critical first step in setting up monitoring systems. Whether data consists of emissions and removals or assigned amounts, the following issues need to be addressed: What are the geographic and temporal boundaries of the monitoring domain? How is it subdivided? In which units are emissions and removals or assigned amounts denominated? The identification of the monitoring domain raises different issues for national inventory systems, entity/project-level monitoring systems and assigned amount tracking systems.

Box 2: **The monitoring domain for national inventories**

The monitoring domain for national inventories, as identified in the IPCC and UNFCCC guidelines as well as in the Protocol, consists of a Party's anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. This includes at a minimum the six greenhouse gases (or gas categories) defined in Annex A of the Protocol. The domain covers actual emissions (and removals) occurring within national territories and off-shore areas over which the country has jurisdiction[10]. The monitoring domain is subdivided into source categories as defined in the IPCC guidelines (and reflected in Annex A of the Protocol). Emissions by sources and removals by sinks are expressed in units of mass, as well as in carbon dioxide equivalent emissions[11] for aggregation purposes. Inventories should be provided annually, from 1990[12] onwards.

In the case of **national inventories**, the IPCC and UNFCCC guidelines, as well as the Protocol itself, provide a clear definition of the monitoring domain (see Box 2). This common framework is essential to ensure the comparability and assess the completeness of national inventories. In practice, Parties may encounter difficulties monitoring emissions and removals from all categories included in the guidelines, as experience with current inventories shows (UNFCCC 1999). Parties may also have difficulties with distinguishing emissions by source categories, which may lead to double counting of emissions and inaccurate overall total estimates. These issues are addressed by IPCC in its good practice work.

In the case of **entity-level and project-level emissions monitoring systems,** the monitoring domain will vary with the purpose for which it is set up. Although IPCC guidelines may provide useful guidance for some aspects that are common to entity/project and national level monitoring systems, it is up to each Party

[10] Except in some specific cases: emissions from road vehicles, from the combustion of wood and wood products, from carbon stored in non-fuel products. Emissions by international transport by ships or aircraft need to be reported, but separately.

[11] Using 100 year global warming potential values provided by the IPCC in its second assessment report.

[12] Or a different base year, according to specific provisions of the Convention or the Protocol.

and/or entity to decide how monitoring boundaries should be set[13]. These are the types of issues that may need to be addressed:

- In the case of a government programme, should participation be voluntary? Should it be subject to government approval or be required by governments? Should participation be restricted to a particular sector (e.g. utility industry), or to entities/projects with a certain size or level of emissions?

- Should an entity separately monitor and report emissions (and removals) of each stack or facility that it operates? Should it aggregate emissions of all the facilities that it operates? Should it monitor and report emissions of all facilities where it has equity? (Mac Mahon 1999)

- Should all greenhouse gas emissions and removals as defined in the Kyoto Protocol be tracked and reported, or only a subset of these emissions and removals?

- Should entities monitor and report actual (or direct) emissions (and removals) resulting from their activities or from the projects they undertake, or should they monitor and report potential (or indirect) emissions (and removals), or both?

- Should entities use source categories as defined in the IPCC guidelines or should they use more detailed source categories that fit their own needs and characteristics? Should each of these gases be reported separately and/or aggregated on a carbon equivalent basis?

- Should emissions (and removals) be monitored and reported on a yearly basis, or should entities provide emissions estimates for shorter periods of time? Should 1990 or any later year be used as a base year?

Parties and/or entities will generally need to balance different quality criteria, like completeness, accuracy, efficiency, transparency, comparability. For instance, Parties may for instance restrict monitoring systems to those sources/gases (e.g. electric utilities) where a high accuracy level can be achieved in emissions estimates. Alternatively, they may aim for more complete monitoring, giving the system a large scope, even if a lower level of accuracy is achieved. Comparability may also be an issue. For example, monitoring boundaries for multinational corporations may need to be handled in a comparable way across countries to avoid double counting. Depending on how Parties handle these issues, monitoring entity (and/or project) level emissions and removals might be more or less useful for improving the national level inventory.

Assigned amount tracking systems differ essentially from emissions monitoring systems in that assigned amounts held by Parties and/or entities, that is, emissions 'allowances' and not real emissions, are tracked. Assigned amount tracking can be facilitated if assigned amounts are denominated in clearly identified *units* and are held in clearly identified *accounts*.

- Each unit could correspond, for instance, to one tonne of carbon equivalent emissions and could be identified by a serial number. These serial numbers would be unique and would mention the commitment period in which the unit was issued and the country of origin (e.g. 1-NZL-000153).

- Every holder of assigned amount units would be required to hold an account. Accounts could be held by the Party or by legal entities under its jurisdiction. Each account would be identified by a unique number as well as by its country of origin (e.g. account number NOR-22). Each account could also be identified by a person representing the Party or the legal entity holder of the account.

[13] In case projects are joint implementation projects, international guidelines might be needed, as proposed by some Annex I Parties.

– The monitoring domain of each national registry would consist of all units held in accounts created in the registry. The number of accounts would depend on the number of entities that would participate in the domestic trading programme. The monitoring domain would also be extended to tracking of each *operation* resulting in a change in the quantity of assigned amount units held by a Parties and/or entities (see Section 2.1.3), in particular transactions between entities, between Parties and between Parties and entities. Transactions would also need to be clearly identified by a unique transaction number, the date of the transaction, the accounts involved in the transaction, the serial numbers involved in the transaction.

3.2 The choice of monitoring methods

Monitoring methods specify *how* to monitor the data defined in the monitoring domain. They determine to a great extent the level of confidence in the monitoring results. The choice of methods is only an issue for emissions monitoring systems. The two broad categories of emissions monitoring methods are presented in Box 3.

Box 3: **Types of emissions/removals monitoring methods**

There are many different emissions monitoring methods, ranging from the most data intensive to the less data intensive methods. In the IPCC guidelines, methods are ranked according to different tiers (1/2/3), which represent levels of complexity and detail.

Emission measurements. The most direct (and most data intensive) monitoring methods consist in continuous or frequent emissions measurements at or very close to the source (field measurements). These measurements usually rely on a specific monitoring device that is placed at the source to measure emissions.

In the US, energy related CO_2 emissions from electric utilities are measured as part of the SO_2 trading programme. Electric utilities can use either CO_2 continuous emission monitoring systems (CEMS) or indirect methods based on fuel measurement. With CO_2 continuous monitoring systems, CO_2 concentration as well as volumetric flows of all flue gas exhaust are monitored in order to calculate CO_2 emissions. With the other methods, fuel flow (using a fuel flowmeter) or fuel usage is measured, as well as the carbon content of fuels using fuel sampling and analysis (Macedonia 1999).

Measurements are only feasible with emissions coming from large stationary sources, like stacks, vents or pipes. Even within this category, proven methods may not (yet) exist for all types of (industrial) processes and for all greenhouse gases that are monitored under the Kyoto Protocol. For instance, it is more difficult to measure CO_2 emissions from fuel combustion in the petrochemical industry than in the electric utility industry, since fuels used are process derived and their composition is not well known (Mac Mahon 1999).

Emissions estimation methods. Estimation methods are based on simple formulae, based on multiplying activity data with (average) emissions factors. Estimation methods vary with the level of detail at which activity data and emission factors can be estimated. Bottom up estimation methods require data gathering at plant/entity level or at technology level. Top down methods allow for data gathering at sector level or regional/national level and use generalised or average emissions factors.

National inventory systems monitor many different greenhouse gas sources/sinks. For the estimation of each greenhouse gas from each source/sink category within national inventories, there is likely to be a

range of possible methods from the most detailed approach (e.g. direct measurements) to the less detailed approach (see Box 3).

Provided appropriate data collection and handling procedures are used, the most data intensive methods are usually considered to be the most reliable, but also the most resource intensive. The IPCC guidelines provide a default methodology, which gives minimum methodology requirements to estimate emissions for each source category. This default methodology gives Parties the option to use as much as possible less data intensive methods, in order to reduce the cost of data collection.

In some cases, in particular for emissions and removals other than energy-related CO_2 emissions, the use of the lower tier or simpler methods may lead to rather high levels of uncertainty in the emission/removal estimate. The IPCC guidelines encourage Parties to use more detailed IPCC methodologies or own national methodologies, as long as they are compatible with the IPCC methodologies.

In a compliance context, it could be decided, not just to encourage, but to require the use of the most detailed methods to estimate emissions/removals from some sources/sinks, when it is shown that simpler methods lead to high uncertainties. However, this requirement might draw too heavily on limited resources and divert them away from better uses. An alternative would be to require the use of more detailed methods only for "important" or "key" sources within the national inventory. These sources would be prioritised within the national inventory system, because their estimates have a significant influence on the country's total inventory (in terms of the absolute level of emissions and/or the trend). As part of its good practice work, the IPCC has defined criteria and elaborated tools that will allow Parties to determine their national key sources (IPCC 2000).

In the case of **entity and/or project-level emissions monitoring systems**, similar methodological choices might need to be made by each Party when designing its domestic programmes. This will depend to a large extent on which greenhouse gas sources/sinks are included in the monitoring domain.

The entity/project-level monitoring domain may include only sources for which relatively simple estimation methods provide acceptable results, i.e. estimates with rather low uncertainty level (e.g. CO_2 from electric utilities). In this case, the choice of methods becomes relatively straightforward, since the simplest methods could be acceptable. More data intensive methods may be available, but the higher accuracy level that they entail may not be considered worth the additional costs[14].

In case entity/project-level monitoring includes different greenhouse gases from a variety of sources (e.g. point and diffuse sources), a Party might choose, just as in the case of national inventories, to allow entities to prioritise the use of available resources. In this case, the use of the most complex methods would only be required for important –or key– sources. The IPCC work on good practice for national inventories might become relevant for entity/project-level monitoring, as it contains information relevant to specific types of sources, such as technology specific emission factors.

Contrary to emissions monitoring systems, methodological choice is not really an issue for **assigned amount tracking systems**, since there is only one possible method to track assigned amounts. This method is quite straightforward, as it is based on tracking each operation that results in a change in the quantity of assigned amount units held in a Party or entities' accounts. There is no uncertainty issue, since each change in assigned amount can be observed and recorded. The quality of the system will depend on how data is collected and handled in the system (see next section).

[14] For energy related carbon dioxide in particular, the use of measurement methods may not be considered necessary. Simple estimation methods based on fuel combustion data and standard emission factors may prove accurate enough (IPCC 2000).

3.3 Data collection, handling and reporting

Data collection, handling and reporting are the basic monitoring activities, which follow a different process for each of the domestic systems considered.

For **national inventory systems**, the agency responsible for the inventory collects activity data, emission factors and/or emission estimates from a variety of sources (see Box 4). These data are used as inputs in a series of calculations that produce final emissions/removals data, which are then reported in the requested format.

In the case of **entity and/or project-level emissions monitoring systems**, data collection and handling usually follows a two-stage process: primary data are collected and handled by entities to produce emissions data that are reported to the monitoring agency. This agency collects and stores emissions data in a database. Data collection and handling systems need therefore to be set up at both entity and national level.

In the case of **assigned amount tracking**, data collection and handling would function like an account management system, i.e. upon request from the account holder.

- In case of transfers and acquisitions, the holder of an account would request that the national tracking (or registry) system removes assigned amount units from the holder's account and transfers them to another account. If the latter account is in another Party's registry, the registry of the first Party would need to notify this request to this other registry, which would credit this account.

- In case of increases or decreases of assigned amounts pursuant to Art. 3.3, 3.4, 3.12 and 4, the Party would need to ensure that the registry system registers these changes by adding new assigned amount units to -or removing existing ones from- the Party's account.

3.3.1 Standardised procedures and information technologies

Although data collection, handling and reporting activities are different for each of these systems, large amounts of information are likely to be transferred from, and transmitted to, these systems. Data handling within the monitoring agency may also involve quite complex procedures and calculations and the use of sophisticated models. Standardised forms of data collection, handling and reporting can facilitate data processing, minimise the risk of errors and achieve higher transparency.

Establishing standard procedures is one of the main goals of a quality management system (see Section 4). Some specific guidance may be needed in some cases at national and/or international level. Standard reporting formats are usually required as they facilitate review of information that is submitted to the end users of data. The UNFCCC guidelines on national inventories already include a common reporting format. In the case of assigned amount tracking systems, a standard format may also be developed to report information on changes in assigned amounts. Specific guidance might be needed to ensure the compatibility of national registries. Standard formats should allow requests for transfers of assigned amount units between accounts in different registries to be processed in a timely manner.

The use of information technology also becomes increasingly important. Electronic data submission from data sources could save time and improve standard collection and review of data at national level. Computer software may also facilitate the handling process (less time consuming hand calculations), increase transparency (easy data access) and provide in-built quality assurance/quality control procedures (see Section 4.2). Public accessibility of emissions/assigned amount data can also be increased.

Information technology may be the only way to allow many entities to participate in entity-level emissions monitoring and assigned amount tracking systems.

For assigned amount tracking systems, one issue that may be raised is that of the settlement period or the period needed to process changes in each account, once a request has been made. It would be desirable to process these changes on a (near) real time basis. In the US SO2 trading programme, EPA processes about 90 per cent of transactions within 24 hours of receipt. Electronic transaction systems, much like on-line banking systems, would allow the transaction process to be quicker and the possibility of errors could be reduced (see Section 4.2). It would also keep the number of staff needed to perform this task at a reasonable level, even if the number of transactions increases.

3.3.2 Data collection for emissions monitoring

Data collection raises specific quality issues for emissions monitoring, both at national and at entity/project level. The relative accuracy of emissions estimates depends on how data are collected, that is how frequently, at which level of detail and with which measurement technique.

Box 4: **Sources of data for national inventories**

Activity data refer to production or consumption data from activities that lead to greenhouse gas emissions (or removals):

- The IPCC guidelines rarely provide default activity data, but give references to international data sources.
- Most activity data in national inventories actually originate from official energy, industry, agriculture/forestry or trade statistics.
- Official statistics may not be available at very detailed (sub-) sector or entity level, or, more simply, may not be available for new types of activities (e.g. production or consumption data for the new gases, HFC, PFC, SF6). In this case, own surveys need to be developed by the inventory agency.
- Alternatively, activity data can be collected on a regular basis from large sources individually.

Emissions factors establish the relationship between emissions and activity data. In order to establish this relationship, sample measurements at the source need be performed:

- The IPCC guidelines provide default emission factors for many source categories, but recommend the use of country-specific emissions factors, since emission factors usually depend on local conditions.
- Country-specific emissions factors may come from different sources: published literature, own measurement studies, entity reporting.

Emissions data can be collected directly if entities report their own emissions estimates

In the case of **national inventories**, the quality of (aggregate) activity data depends on the number of emissions sources from which activity data is collected and how representative these sources are as well as the frequency of surveys/entity-level reporting upon which estimates are based. The quality of average

emissions factors depends on the sample measurement process and frequency, and how representative the sample is within the source category[15].

For **entity/project-level monitoring**, the quality of activity data depends on how data collection is organised within the entity, its frequency, its ability to track all production and consumption flows. The quality of emissions factors depends on the frequency of measurement samplings at the source and how these samplings have been done. An entity may use default emissions factors (taken from literature, or estimated by other entities). However, these emissions factors may not be representative of the conditions of production in this particular entity. The quality of emissions measurements also depends on the robustness of the measurement devices and the frequency of measurements.

In view of the importance of data collection procedures for data quality, monitoring methods should therefore provide clear indications on how data should be collected. The use of intrinsically more detailed emissions monitoring methods may lead to a lower data quality if data are collected from too few sources or too infrequently.

3.3.3 Data reporting

Reporting is essential to allow for effective review by the end users. Insufficient or too detailed information might, however, reduce the effectiveness of this review.

In the case of **national inventories**, the UNFCCC process has progressively strengthened the reporting requirements. The revised UNFCCC guidelines include not only reporting of emissions data, but also reporting of emissions factors and activity data, detailed information on data calculations and recalculations (for inventories of previous years). They also include a description of methodologies and assumptions used in each sector as well as information on data gaps, uncertainty and on any verification (or QA/QC) procedures.

These reporting requirements should allow for an in-depth review of the quality of inventory information provided by Parties, in terms of transparency, comparability, completeness, consistency and accuracy [16]. Experience with these reporting guidelines will be necessary to assess whether the information that is requested is adequate for review. It may be that the requested information is insufficient or too detailed for Parties to report and for the secretariat to review. In order to facilitate the review process, it may also be that reporting could focus more on information regarding the management process, including on planning, documentation and quality assurance/quality control procedures.

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15 For carbon dioxide emissions from fuel combustion, emission factors are an intrinsic quality of fossil fuels and do not depend on the combustion process. In this case, emissions factors can be rather easily estimated from limited fuel samples. For other emission factors, emission factors depend on the production or consumption process, in particular the type of technology used, and the conditions in which it has been used. There may be much variability within each source category, so that estimation of average emissions factors requires more frequent measurements from a large number of representative samples.

16 A two-year trial period is foreseen to assess these reporting requirements in light of the experience gained by Parties and the secretariat.

For **entity/project-level monitoring systems**, reporting requirements will essentially vary with the type of monitoring systems. In the US SO_2 trading programme (see Box 3), reporting essentially consists in submitting quarterly reports containing the hourly emissions of SO_2, NO_x and CO_2 and heat input (Kruger et al. 1999). In this case, there are very strict requirements for monitoring systems at entity level, including standard verification and certification procedures during the monitoring process. When more choices are left to entities about methods and technologies used, one would expect the reporting of other types of information in addition reporting on emissions data (e.g. methods and assumptions used, information on data gaps, uncertainty assessment and verification procedures).

For **assigned amount tracking systems**, reporting could be annual, in order to complement annual submissions of emissions inventories. There could also be advantages in more frequent reporting to provide the end user (the international community) with sufficient, but not too detailed, information on trading activity. Information could therefore focus on the balance of a Party's account and the total balance of all entity accounts at the start and at the end of the period. Information could also include the quantum of assigned amount units (AAUs) transferred from the Party account to entity accounts and from entity accounts to the Party's account as well as the quantum of AAUs traded internationally both by the Party account and by the entity accounts (New Zealand 1999).

4. The management process

This section provides an analysis of monitoring systems from a managerial perspective. Monitoring systems are not just a set of basic technical functions, but should include a wider set of "management" functions, such as planning and documentation, quality assurance/quality control as well as organisation and staffing.

These functions can ensure that there is a concern for quality throughout the monitoring process. This reduces the need for data quality assessment and review by the end users of data. The management process cannot improve quality beyond what is allowed by the methods used in the monitoring process. However, it can help prioritise efforts to improve monitoring activities by identifying which areas would result in the biggest data quality improvements.

The general characteristics of this management process are common to all monitoring systems discussed in this paper. Pertinent standards and guidelines already exist at international level, such as the ISO 9000 series, and apply to all data quality management systems. However, they need to be adapted to the specific characteristics of emissions monitoring and assigned amount tracking systems.

The IPCC has just developed "good practice" guidance as to what should be the minimum requirements in terms of quality assurance/quality control and documentation for national inventories (IPCC 2000). This section is of a more general nature and is mainly based on the discussion of quality management procedures for emissions monitoring in EIIP 1996/1997. It is assumed that these procedures can be adapted to cover assigned amount tracking systems, as they mostly refer to general characteristics of quality management.

4.1 Planning and documentation

4.1.1 Elements of planning and documentation

As a general rule, all the different objectives, methods, procedures, activities of monitoring systems should be planned and documented.

During the planning phase, the purpose and scope of monitoring systems can be formally identified, possibly in a written statement, as they define the general objectives of the monitoring activities. One possible way to further define objectives for each of these monitoring systems is to formally identify *data quality objectives* (see Box 5). A *work plan* should also identify and describe the methods, technologies and procedures used during the monitoring process (including quality assurance/quality control procedures). For entity-level emissions monitoring systems, this might be covered by a monitoring, reporting and verification protocol. The organisational structure, staffing and responsibilities could also be clearly spelled out, e.g. in an organisational chart. This detailed written record of objectives, procedures and planned activities should of course incorporate any national or international guidelines or requirements.

Documentation should include, beside a record of objectives, procedures and planned activities, a record of *actual* activities (including data collection and handling, calculations and QA/AC activities) as well a report on monitoring results and an assessment of its quality (EIIP 1996/1997). All the information that is kept in record files will not usually be reported to the end users, but it should be easily accessible to these end users, for verification purposes.

In addition, public accessibility of key data, in particular through the internet, may also be desirable.

Box 5: **Data quality objectives (DQOs)**

Data quality objectives are formal statements of what could be achieved in terms of transparency, comparability/compatibility, consistency, accuracy/confidence, completeness, timeliness or efficiency. These quality criteria are always used at least informally to assess data quality. DQOs simply make these criteria explicit.

A more difficult step would be to define DQOs quantitatively with the help of data quality indicators (DQIs). For instance, transparency could be further specified to mean that all key data should be accessible on the web. Timeliness could be specified in terms of a maximum number of days for processing (emissions or assigned amount) data collected from entities. Completeness could mean for instance that a 95 per cent completeness of the national or entity-level inventory should be reached.

Objectives in terms of accuracy/confidence could also be set in quantitative terms.

- For national inventory systems, this would depend on the availability of reliable quantitative measures of uncertainty. The IPCC in its good practice work provides different tools for Parties to estimate uncertainties.

- For entity/project-level monitoring systems based on direct measurement, reliable quantitative measures of uncertainty should be available. When estimation methods are used for monitoring emissions, this may be more difficult to achieve.

- For **assigned** amount tracking systems, accuracy/confidence could have a different meaning. There is no estimation uncertainty as the number and type of transactions can be observed and reported with accuracy, but the overall objective of tracking systems could be that each assigned amount unit held in the national tracking system is unique (i.e. not held elsewhere).

Data quality objectives can become key management tools as they can guide the choice of methods, technologies and procedures that will be used to perform the key functions of monitoring systems.

4.1.2 Role of planning and documentation

Planning and documentation plays many different roles in a management process.

- A detailed record of data quality objectives, planned activities and actual activities is essential for transparency. This transparency is needed to perform quality assurance/quality control activities throughout the monitoring process. It is also needed to facilitate review or verification by the end users of data. Dissemination of information, in particular through the internet with user friendly interface, may also encourage public review of emissions performance and emissions trading activity, which may become as important as more formal review processes.

- Planning and documentation allows the monitoring personnel to rely on proven standardised procedures for data management. This minimises the risk of errors and inconsistencies in the monitoring process. By identifying the tasks and responsibilities of the monitoring personnel, planning also gives staff a clear view of their activities. An early involvement of the personnel in defining these tasks and responsibilities can lead to a higher degree of commitment in fulfilling identified tasks. A

good planning and documentation system also allows for institutional memory, so that key staff may leave and be replaced without much disturbance in the monitoring process.

- Planning and documentation has also an institutional function. It allows the systems manager to institutionalise the monitoring process and to spell out formal arrangements, possibly in a legal form (see Section 5.1.2). It helps the systems manager to get the support from the higher management and, perhaps even, to increase funding for monitoring activities. It also informs the higher management about what it can expect from the monitoring systems.

- At entity/project level, the data quality objectives and a monitoring, reporting and verification protocol are an essential tool to define the legal requirements of entities in emissions monitoring. Such protocols can be tailored to each specific type of entity/project.

If guidance is deemed necessary, how specific should guidance on planning and documentation be for each of the monitoring systems? It could be defined in terms of general requirements to set data quality objectives, elaborate work plans or keep record of all activities. Or guidance could be much more specific, in terms of which data quality objectives should be reached, which procedures should be adopted, which information should be recorded or made publicly accessible.

The UNFCCC guidelines already require that record keeping should include all information needed to allow the reconstruction of the inventory by expert review teams. They also require that information reported be published. In the case of assigned amount tracking systems, more detailed information (than what would need to be reported) could be made publicly accessible. This might include all relevant information on each account and assigned amount units held in each account, on each change in assigned amount (pursuant to Art. 3.3., 3.4., 3.12 and 4) as well as on each transaction (including transaction number, data of the transaction, accounts involved in the transaction, assigned amount units involved in the transaction) (USEPA 1999).

4.2 Quality assurance/quality control

4.2.1 Types of quality assurance/quality control activities

Quality assurance/quality control (QA/QC) activities can be defined in different ways[17]. This definition is adapted from EIIP, 1996/1997:

- QC is a system of technical activities implemented by the personnel in charge of monitoring to measure and control data quality during the monitoring process. It is designed to provide routine checks and documentation points to verify data quality, to identify and reduce errors and omissions, to ensure consistency in the monitoring process as well as to facilitate internal and external review processes.

- QA is a system of review and audit procedures conducted by personnel not actively involved in the monitoring process. It is based on independent, objective review by a third party, which assesses data quality and the effectiveness of procedures, including QC activities.

[17] Under another definition, quality control activities are those procedures and tests that can be performed during the planning and development of an inventory to ensure that the data quality objectives are being met. Quality assurance describes the activities that are completed after the development of a product, usually by an independent party to verify that data quality objectives were met and that the product conforms to specifications (IPCC 1999). Both definitions are used by IPCC.

QA/QC activities are meant to address different issues that affect data quality:

- Technical errors are directly related to the methods and technologies used for monitoring purposes, such as calculation errors (incorrect use of spreadsheets, databases, software, mathematical errors), use of incorrect data, use of incorrect methodology and/or assumptions, incompleteness, double counting;

- Procedural errors result from unclear and ineffective management, inadequately trained staff, improper planning, lack of adequate quality assurance, lack of data tracking and handling protocols, and other problems related to how the work gets done. Avoiding procedural errors will reduce the likelihood of technical errors (EIIP 1996/1997).

- Uncertainty refers to inherent uncertainty of emissions estimates, as distinct from technical errors in processing data.

- Sensitivity refers to how changes in input parameters affect the overall data quality.

There are many types of QA/QC activities that address these different issues and many variants within each type. Box 6 presents a general overview of these different QA/QC methods, based on methods used for emissions monitoring.

4.2.2 Role of QA/QC

QA/QC activities are an essential function in the management process. For emissions monitoring systems, whether at national and/or entity/project level, QA/QC activities are essential not only to minimise errors and inconsistencies, but also to assess and reduce uncertainty of emissions data. For assigned amount tracking systems, QA/QC activities might focus on ensuring transparency or systems compatibility, or avoiding errors, such as the possible presence of invalid assigned amount units.

QA/QC activities performed during the monitoring process should reduce considerably the need for ex-post review. For national inventory systems and assigned amount tracking systems, this might help to reduce the burden of expert review teams under KP Art. 8. For entity-level emissions and assigned amount tracking, this might also reduce the burden of controlling the data that is reported by entities.

However, there are many possible QA/QC activities. Which methods should be selected? How specific should guidance be? How much time, efforts and resources need to be spent on QA/QC activities? These are the main issues that need to be addressed in order to elaborate guidance for QA/QC.

Some general QA/QC activities might pertain to all types of monitoring systems, as they are part of any data quality management system. Other QA/QC activities will more specific to the type of monitoring system considered. When monitoring systems are based on standard methods and technologies, standard quality assurance procedures might already exist. In the US SO_2 trading programme, monitoring systems used by entities are audited and certified. This includes assessing the performance of standard measurement devices, like continuous monitoring systems (Macedonia 1999).

Standard QA/QC procedures might be more difficult to define for more complex emissions monitoring systems, involving various estimation methods, whether at national, entity or project level. The IPCC has developed good practice guidance as to what could be the requirements in terms of QA/QC for national inventories. It includes different levels of QA/QC methods for different types of emission sources. More complex QA/QC methods would be needed in case of important sources (see Section 3.2) or sources which have not been estimated before. This effort might also be useful for developing QA/QC requirements for entity/project-level emissions monitoring systems.

Box 6: **General overview of QA/QC methods**

Data comparison and *sample calculations* refer to a variety of checks used to identify technical errors. Data comparison is based on checking the "reasonableness" of data and/or whether they fall within accepted ranges, by comparing data to a reference value or to other data sets. They can rely on expert judgement, on statistical methods or on direct measurements at the source ("ground truth verification"). Some of these checks can also be computerised. Sample calculations are used to check errors in (spreadsheet, model or hand) calculations by replicating the calculations by hand or electronically. Many of these checks can be performed by the monitoring personnel through routine QC procedures. They can also be performed by a third party during peer reviews or technical audits (see below).

Uncertainty assessment refers to different methods to evaluate uncertainty in emissions estimates. When emissions are measured (directly or indirectly), statistical measures of bias and precision can be used to define data uncertainty (or relative accuracy). When standard statistical methods are not possible, quantitative measures may be based on expert judgements. Semi-quantitative measures of uncertainty can also be used, like data ranking systems. If this is not possible, uncertainty can be assessed in a qualitative way, by identifying the strengths and weaknesses of emissions estimates. Uncertainty assessment can be a key management tool if it is used to define data quality indicators that measure accuracy/uncertainty. These indicators can be used during the verification process to assess whether certain data quality objectives are met (see Section 4.1).

Sensitivity analysis is a systematic study of how changes in input parameters affect the output. Sensitivity analysis is a key tool that can be used during the planning phase to prioritise efforts to improve data quality. The quality of estimates for some sources, whether emissions, activity data or emission factors, can be improved in priority, if it is shown that they have a large impact on overall emissions estimates (for instance, if the source is relatively large).

Peer review is a review of calculations, assumptions, and/or documentation by an independent expert. This is generally accomplished by reading or reviewing documentation, but is generally not as rigorous as a technical audit. Peer reviews help to ensure that data, assumptions and procedures are reasonable and meet expectations as judged by persons knowledgeable in the field. Reviews may be more or less detailed: reviewers might be given a detailed checklist of elements to be reviewed, or may simply provide general comments.

Audits are a systematic evaluation to determine the quality of a function or activity. It is important to recognise that audits can have different objectives, as they may evaluate different functions during the monitoring process. They can evaluate the technical specifications (methods and technologies used for data collection and handling) or the entire management of monitoring systems (e.g. organisation and staffing, documentation, verification procedures). They can be used to assess the performance of an equipment used to collect measurement data (e.g. continuous monitoring systems) to check whether it operates within acceptable limits. They can be used to assess the quality of the data and whether the data quality objectives have been met. They can be used to assess whether all the procedures have been followed and if there are not technical or procedural errors.

These audits correspond to different stages of the monitoring process. Audits that evaluate technical specifications and the management system might best be performed at the early stage of the process (i.e. after the planning phase). Audits that evaluate whether the data quality objectives have been met and the procedures followed are performed towards the end of the process. Ideally, at least two audits should be performed, one in the beginning and one at the end of the monitoring process. Audits can be external or internal. External audits are usually the preferred option: these are audits performed by personnel that are independent from -and do not report directly to- the monitoring systems manager. These auditors need not necessarily come from an audit firm. Staff within the monitoring team can perform internal audits. However, an audit performed by a third party may be more valuable in the long term.

Independent auditors or reviewers need not be considered as inspectors, but rather as helping to improve the monitoring process. However, when problems are identified during the audit or peer review, the monitoring system personnel should be held accountable for following through on the recommendations of the reviewer or auditor.

Specific guidance for assigned amount tracking systems might include different QA/QC methods, such as auditing and certification.

Certification of monitoring systems by accredited bodies would require agreed audit procedures. Certification might be required under national or international regimes for any of these monitoring systems. Certification of national inventory systems, assigned amount tracking systems and/or entity/project-level emission monitoring systems has, for instance, been mentioned by some as part of eligibility criteria for participation in joint implementation and/or emissions trading.

4.3 Organisation and staffing

An important element of effective management systems is that organisation and staffing is identified during the planning phase at the same time as procedures are specified for data collection, handling, documentation and verification. This allows staff members to have a clear view of their role and responsibilities. There is therefore no duplication of efforts or missed step in following the monitoring procedures. This also allows for an early identification of staffing and training needs. The organisational structure could be presented in a chart where all key staff are identified with associated responsibilities.

Ideally, different levels of responsibility could be identified within the organisation structure. However, this might be difficult if resources are limited:

- The overall responsibility of a monitoring system should be assigned to one person. At government level, such as for a national inventory system, this person could report directly to the higher management level of the responsible agency. He or she should make sure that he or she has the support of higher management and that the latter is regularly informed of the monitoring process. At entity level, this person could report directly to the higher management. This may guarantee the necessary independence from operating units that are responsible for the greenhouse gas emissions.

- In addition to the monitoring systems 'manager', it may be useful to identify staff responsible for each emission sources (for emissions monitoring systems at national and entity/project level) as well as a person responsible for the data management system (in particular if this is a computerised system).

- Finally, it may also be useful to identify one person responsible for verification procedures (see Section 4.2). This person (or "QA co-ordinator") should report to the higher management and be independent from the monitoring system manager. He or she would conduct audits of the monitoring system. An alternative (or complementary) approach is that a member of the monitoring systems personnel is responsible for hiring or consulting an (independent) auditor or peer reviewer. This audit/review process should be considered as an integral part of the monitoring process.

Only large countries or companies might be able to afford an elaborate multi-person organisational structure with differentiated responsibilities. Sufficient staff may, however, be a key to ensuring effective monitoring systems. By definition, monitoring systems need to handle vast amounts of information. For national inventory systems, staff has so far been very limited in many countries (Lanchbery 1996). A reduced staff may prevent the use of more detailed methods for estimating emissions and the collection of disaggregated data.

The technical competence of the monitoring personnel is also key to the success of the monitoring activity. Training programmes might be needed to improve the overall level of expertise within the monitoring team.

It may be difficult to specify any guidance in terms of staffing and organisation, since organisational structure and staffing will vary with the types of organisation and management culture. However, monitoring systems could identify at a minimum the person responsible for the monitoring activity and/or the existence of a training programme. Identifying staff weaknesses in terms of size, training or organisation can also be part of auditing/reviewing monitoring systems (see Section 4.2).

5. The institutional context

The institutional context describes the arrangements that establish monitoring systems as well as the relationship between monitoring systems and other institutions that contribute to monitoring process. The institutional context also refers to the overall knowledge and resource base of a country, within which both government and entities draw resources or knowledge in order to set up monitoring systems.

These different institutional features of monitoring systems are rather country-specific. It may be more difficult to define specific guidance for institutional arrangements as compared to core technical functions or the management process. However, their importance for monitoring systems should not be overlooked. The difficulty to set up monitoring systems of a sufficient quality may lie in the overall institutional context. A number of issues might be raised that concern most institutional frameworks within which monitoring systems operate. This may help provide a common understanding of key institutional issues. It may also help prioritise capacity building programmes that are set up either domestically or internationally (IPCC 1998b).

5.1 Institutional arrangements

5.1.1 Organisational arrangements

The lead institution(s) legally responsible for the monitoring activity should be clearly identified. It may be that responsibilities are shared among many different ministries or agencies, possibly across different regions (as in some federal states). However, in this case, there is a risk that responsibility is diluted, in particular if co-operation between these bodies is not optimal for a variety of reasons.

Even if responsibility is centralised into one lead institution, there may be different organisational arrangements. Monitoring systems can be:

- run directly by the agency/ministry or agencies/ministries (e.g. in the case of interdepartmental task forces) that are constitutionally responsible for such activities; or, alternatively,

- contracted out to specialised agencies, or private institutions, that are funded and report to the responsible ministries or agencies.

Each of these arrangements may have advantages and disadvantages. Since monitoring systems involve very technical functions, these specialised agencies and private institutions might run them quite efficiently. However, in this case, responsible ministries or government agencies should not just be nominally responsible. They should retain the institutional capacity to verify how the work is done or, at least, to ensure that appropriate audits or reviews are conducted (see Section 4.2) and that information is widely accessible, and that documentation is transparent and complete. Otherwise, the monitoring process tends to be very secretive “thereby obscuring an already obscure process” (Lanchbery 1996).

Some monitoring systems might be better suited than others for contracting to specialised agencies or private institutions. For instance, assigned amount tracking systems might be run eventually by private companies, as it involves rather technical, but straightforward activities that could easily be checked by the responsible ministry or agency or an independent agent.

Another organisational issue is the relationship between monitoring systems. The three types of monitoring systems considered in this paper are closely related (see Section 2). There may therefore be some advantages in integrating these systems into one organisational structure, even if these systems can in principle be run quite independently of each other on a daily basis.

5.1.2 Legal status

What seems to be particularly relevant is that monitoring systems are institutionalised, i.e. that they are more than ad-hoc arrangements and that they have a clear legal status and an official existence within the institutional structure. Hence, the importance of the planning phase (discussed in Section 4.1), where the main tasks, staffing and organisation of monitoring systems are clearly identified, as well as the official(s) responsible for these monitoring systems within the responsible ministry/agency. These arrangements can be officially recognised by the responsible ministries/agencies, or by legislation, and a permanent budget line clearly identified.

These arrangements should also remain relatively consistent over the years. While there may be advantages in reviewing them regularly and, in case systems are contracted out to private companies, in organising regular calls for tender, a certain minimum number of years is necessary for these systems to be established and run efficiently. Otherwise, there may be gaps in institutional knowledge and learning (OECD 1999b).

In many countries, inventory compilation contracts have been typically small and intermittent (Lanchbery 1996). In a compliance context, this is certainly not advisable, as there is no assurance that the quality of inventory preparation will be improving or at least remain constant. More permanent arrangements would optimise the effectiveness of training programmes for the monitoring personnel, since expertise would remain in the same structure (IPCC 1999b).

The same can be said for entity/project-level emissions monitoring systems (or assigned amount tracking systems) that are likely to be set up in the future. Current experience with activities implemented jointly, for instance, shows that adequate institutional structure and knowledge is lacking in many transition countries. This prevents the development of monitoring systems that could be used as a basis for joint implementation or emissions trading under the Kyoto Protocol (Klarer 1999).

Legal recognition may not be sufficient, however. Monitoring systems also need clear support from the higher management in the responsible institution. They should be identified as a priority task in the overall management structure of the responsible institution. Although what is the appropriate level of support is difficult to assess, this can be a quality criterion that could be checked as part of an audit that evaluates the management process (EIIP 1996/1997). However, it is also possible that monitoring activities usually rank low among the responsible ministries or agencies.

More generally, the responsible institution(s), and higher management, may themselves have a relatively weak position in the overall institutional structure. The Ministry or Ministries responsible may have an inferior status compared to other Ministries, have fewer resources, and be further away from the political power, where decisions are made concerning budget and political priorities. These problems might be much more difficult to solve, even in the long run.

5.1.3 The regulatory framework

There can be very different types of relationships between monitoring systems and other organisations, like statistical agencies or entities.

In the case of national inventories, collaboration may rely on established but voluntary co-operative arrangements, like those with industry that provide data for monitoring systems and government statistical offices in the UK (Salt and Greene 1996). Informal arrangements might well provide monitoring systems with a regular flow of first hand information, but raise questions as to whether this information is of sufficient quality or even unbiased (OECD 1999b). The following issues should be addressed:

- Do inventory developers have access to information regarding methods, technologies and possible QA/QC activities? Are there comparable procedures across different data sources?

- Are they involved in the monitoring process, e.g. for selecting the best methods or verifying data? Can they suggest any changes?

- Are there ways for the government to verify information from industrial sources, which may set industry in good light?

There may be advantages in more formal arrangements, whereby entities are required by law to co-operate with the statistics agency or monitoring system, comply with clear monitoring and reporting guidelines and be subject to a verification process. This issue might become more and more important if this type of information is increasingly used in a compliance context.

Entity/project-level emissions monitoring systems and assigned amount tracking systems are more likely to be part of a regulatory framework, since they would be set up in connection with regulatory programmes. However, even in this case, the compliance framework might be more or less well defined: do monitoring systems have the legal authority to enforce legal requirements to submit data? Are there consequences clearly defined in case of non-performance? Do monitoring systems have the capacity to verify data that are reported by entities? Is there a requirement that QA/QC procedures be followed at entity/project level?

Monitoring systems can also benefit from being closely linked to regulatory authorities at key stages of the monitoring process (OECD 1999b):

- In the planning stage, regulatory authorities can ensure that the monitoring process is consistent with the intended use of the monitoring results as well as national and/or international requirements.

- In the verification stage, regulatory authorities could also ensure that entities effectively report emissions and/or assigned amount data and could be associated with any controls or spot checks of entity-level monitoring systems.

- Finally, regulatory authorities are the main users of monitoring systems, since the data will be used to assess whether entities comply with their domestic requirements and whether the Party is on track to be in compliance with international obligations. They should be familiar with the methods, technologies used and be regularly involved in the management process, in order to interpret the data correctly.

5.2 Relationships with other institutions

Monitoring systems may need to rely on many different organisations that are independent from the institutions directly responsible for the monitoring activity. These institutions should be clearly identified. In addition, it may also be useful to assess their strengths and weaknesses, as these may be critical for ensuring data quality.

5.2.1 The statistical system

The statistical system (or any similar source of official data) is the main source of data for national inventory systems, since it provides activity data (energy data, production and consumption data, import and export data, tax collection data). The quality of emissions (and removals) data in national inventories is highly dependent on the quality of statistical activity data.

As discussed in this paper, this quality also depends on the management process as well as the institutional context in which the statistical system operates. The statistical system may not have enough resources to use the best methods and technologies for data collection and handling and for data verification. The institutional context may weaken further such systems if it is not considered a high priority.

5.2.2 Entities

Entities, i.e. private/public companies that are the sources of pollution, will be the main sources of data for entity/project-level emissions monitoring systems (greenhouse gas emissions). They can also be important sources of data for national inventory systems (greenhouse gas emissions, activity data, emissions factors) and assigned amount tracking systems (transactions under domestic credit and/or allowance trading programmes and/or Kyoto Mechanisms).

The same basic institutional issues identified for government institutions can be addressed in the case of entities:

- What is the status of greenhouse gas monitoring activities, if any, within the entity? Is it a permanent activity?

- Is there support from higher management? Is it independent from the operating units?

- Is there a centralised data collection system? If not, are data collection systems co-operating within the entity?

- More generally, is there a tradition of “performance monitoring”, whereby key environmental and activity data are measured, verified/audited and publicly accessible? Is there a certified environment/quality management system in place?

Government-funded programmes, targeted for instance on small and medium sized firms, may encourage high-quality environmental monitoring and reporting (including of greenhouse gas emissions/removals).

5.2.3 Other organisations

Other organisations play many different roles in the context of monitoring systems. Though these organisations are not explored in-depth here, it is important to notice that the quality of their services is also critical to the quality of the monitoring activities. Here is a list of organisations that can be involved in the monitoring process:

- Environmental consulting firms can be contracted out by the monitoring agency or the entity to perform some specific task, which can go from conducting a survey to being used as a peer reviewer or provide specific training
- Environmental auditors can be contracted to perform audits at entity, project or national level
- Environmental organisations can be used as peer reviewers
- Research institutes can be contracted out to conduct some specific studies (e.g. on process parameters)
- Engineering firms can provide new monitoring devices and specific training for their use
- Computer firms can be hired to set up computerised monitoring systems and/or to provide specific training
- Brokers and stock exchanges may be used to set up a market of assigned amount units.

5.3 The country's knowledge base

Well-managed monitoring activities may need to rely on many different areas of expertise. Whether this expertise exists within the country has usually little to do with climate change, but on the overall knowledge base and business climate in the country.

More general questions may therefore be asked in order to identify a country's weaknesses and strengths in its overall knowledge base: Are there many research institutes, possibly of an international stature? Does the business community/government have a tradition of quality management, performing external/internal audits, and publicly reporting on its own environmental management performance? Are there leading engineering/computer technology firms in the country? Is there a large trading community (i.e. brokers, stock exchanges)?

This set of questions may not be relevant to define any guidance for monitoring systems, but might help to identify training needs. A priority for capacity building might be to set up training programmes in a few related disciplines to expand the circle of experts in the field. In particular, too few experts could prevent the extensive use of independent reviewing/auditing to improve monitoring systems, as it is now the case for national inventory systems (Lanchbery 1996). The involvement of environmental organisations as independent reviewers is also important (OECD 1999b). However, this also raises larger issues: is there a thriving NGO community? Is it a public voice within the country? Is it usually involved in reviewing government/entity environmental performance?

Other issues relate to how well government institutions and entities draw on existing resources:

- Are there many forms of bilateral or multilateral co-operation between institutions?

- Are training programmes part of the policies of government/entities?
- Does the research community usually co-operate with government/industry?
- Are environmental programmes open to public scrutiny, including by environmental organisations?
- Are there many forums/networks where information can be disseminated?

The latter set of questions may help identify the possible needs for funding national/regional networks, through which experts can have access to country-specific data (IPCC 1998b). These networks may also provide a basis for an enhanced co-operation between government, industry and the research community in this field.

6. Conclusion

Sound development of the different monitoring systems at all three -technical, managerial and institutional- levels is needed to ensure sufficient data quality. Basic technical functions, in particular the choice of monitoring methods, set the overall level of quality monitoring systems can aim for. An efficient management process minimises the risk of errors and inconsistencies in performing these basic technical functions. A strong institutional framework makes it possible to improve the quality of monitoring activities and to set up an efficient management process.

The development of these different features raises common, but also different, sets of issues for each of the monitoring systems considered in this paper.

Core technical functions

The choice of methods is the main concern for national inventory systems. For each greenhouse gas and each source/sink category, there is likely to be a range of possible methods from the most detailed (e.g. frequent field measurements) to more or aggregate estimation techniques. Measurement based and other data intensive methods are considered to be the most accurate, but also the most resource intensive. It may not be useful or feasible to prescribe the use of specific methods for each emissions source as it could limit the continuous development of methods that best suit specific circumstances in a particular country or entity/project. One possible option is to identify "key sources" in each country for which more complex methods might be required. The IPCC provides the tools for Parties to define which are these key sources (IPCC 2000).

The same methodological issue might arise with entity/project-level emissions monitoring systems, unless their monitoring domain is restricted to those emissions sources that can be estimated with relatively simple methods. Defining the boundaries of the monitoring domain for this type of monitoring systems is likely to be a critical issue for entities, since it may be linked to specific emission reduction programmes.

As regards assigned amount tracking systems, the choice of methods is not really an issue, since there is only one possible method for tracking changes in assigned amount. A clear identification of the tracking domain, timeliness (in processing trades) and compatibility between systems seem to be the most relevant issues in setting up such systems. Electronic data processing, much like on-line banking systems, would make monitoring much easier. More generally, electronic data collection, handling and reporting would benefit the development of all types of monitoring systems.

The management process

The general characteristics of an efficient management process are common to all monitoring systems discussed in this paper. Pertinent standards and guidelines already exist at international level and apply to all data quality management systems. They should be supplemented by procedures that are adapted to the specific characteristics of emissions monitoring and assigned amount tracking systems. These procedures might be more or less resource intensive.

The IPCC has developed "good practice" guidance on quality assurance/quality control and documentation for national inventories (IPCC 2000). It identifies different tiers for QA/QC, with increasing levels of complexity. This effort might also be useful for developing entity/project-level emissions monitoring systems. A similar exercise could be undertaken for assigned amount tracking systems.

Developing an efficient management system may be quite resource intensive, in particular when new systems need to be set up, or when new methods need to be used. However, it helps reduce the burden of data quality assessment and review by end users of data, which might in turn save resources.

The institutional context

The different institutional features of monitoring systems are very country-specific. However, a number of issues might pertain to most institutional frameworks within which monitoring systems operate. The main issues identified in this paper are common to all types of monitoring systems:

- Are there institutional arrangements that establish monitoring systems? Is responsibility clearly defined? Is the support from higher management sufficient? Are there formal arrangements, or even legal authority, for collecting and verifying data from different sources? Is monitoring part of a domestic compliance and enforcement system (in particular, for entity/project-level monitoring systems)?

- Which are the institutions that collaborate in the monitoring process? What are the strengths and weaknesses of these institutions?

- What are the strengths and weaknesses in the country in terms of expertise needed to set up monitoring systems? Are there many forms of co-operation between government, industry and research institutions to exchange information on monitoring activities?

Guidance might be defined for some of these key institutional features. At a minimum, Parties might want to require that the responsible institution(s), as well as institutions that collaborate in the monitoring process, be clearly identified. Other options for guidance might be requirements that monitoring systems have a clear and permanent status within the institutional structure, be reviewed by independent third parties and that they have legal authority to collect necessary data.

An assessment of the strengths and weaknesses of institutions might also provide insights into the specific capabilities of each Annex I Party in achieving good practice in their monitoring systems.

A possible way forward

Table 3 below presents an indicative list of key elements of domestic monitoring systems for which guidance could be developed at national and/or international level. These are generic characteristics that cut across differences between monitoring systems. Priorities for the further development of each system may differ, depending on what has already been achieved, at national and/or international level.

For **national inventory systems**, the IPCC good practice work covers a wide range of relevant issues. It is mainly concerned with providing guidance on methodological choice, uncertainty assessment, quality assurance/quality control and reporting and documentation. The IPCC provides tools to select methods and procedures. However, it is up to Parties to the Convention (UNFCCC) to define minimum requirements for these different elements. Difficult political choices may need to be made on how to use IPCC good practice work. As regards other management functions, like planning, organisation and staffing, and institutions, more analytical work may be needed to further develop what guidance might look like on these issues. In view of the specific circumstances of each country, it may be that guidance can only be very general on these matters.

There exist some (non-governmental and governmental) initiatives at this stage to develop guidance for **entity/project-level emissions monitoring systems**. Common approaches might facilitate the development of the Kyoto Mechanisms. For entity-level monitoring, it is unlikely this would be in the UNFCCC framework, since it is not required under the Kyoto Protocol. The IPCC good practice guidance is also relevant for entity-level monitoring and may provide some insights into project-level monitoring systems as well.

Assigned amount tracking systems are the least developed of all systems, but also probably the simplest to develop and implement. Current proposals focus on a clear identification of the monitoring domain, reporting and public accessibility. Further elaboration of registry systems might focus on the data acquisition and handling process, in particular on how systems in different countries link up as well as on timeliness of data processing. Management and institutional issues may also be discussed, although they may not be as critically important for these systems as they are for national inventory systems.

Table 3: **Indicative list of key elements of domestic monitoring systems**

Core technical functions	
Identification of monitoring domain	*Identification of geographical and temporal boundaries, domain categories or subdivisions, units of measurement*
Choice of monitoring methods	*Procedures to identify appropriate methods for source categories (for emissions monitoring)*
Data collection, handling and reporting	*Standardised procedures/formats for data collection, handling and reporting, electronic data submittal and handling* *Indication of measurement process/frequency, number/representativeness of sources (for emissions monitoring)* *Reporting on key data*
The management process	
Planning and documentation	*Definition of data quality objectives (possibly in quantitative terms), elaboration of a work plan or monitoring protocols, identification of organisational structure, staffing and responsibilities, record of actual monitoring activities, report of the monitoring results and assessment of its quality, public accessibility*
Quality assurance/ quality control	*Procedures to select QA/QC methods (i.e. data comparison, sample calculations, uncertainty assessment, sensitivity analysis, peer review, audits)*
Organisation and staffing	*Identification of lead person responsible and other levels of responsibility (e.g. QA co-ordinator), staff size and technical competence*
The institutional context	
Institutional arrangements	*Identification of lead institution(s) responsible and other levels of responsibility (e.g. specialised agencies), relationships between monitoring systems, existence/permanence of legal arrangements, support from higher management/political authorities, legal authority to collect data, domestic verification process, enforcement powers, involvement of regulatory authorities*
Collaboration with other institutions	*Identification of organisations (statistical system, entities, environmental organisations, audit firms) collaborating in the process; third party review/audit*
Knowledge base	*Situation of government, business and research community ; existence of networks and training programmes*

7. References

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8. Glossary

AAUs	Assigned amount units
AIJ	Activities implemented jointly
AIXG	Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC)
CDM	Clean Development Mechanism (defined in Article 12 of the Kyoto Protocol)
CEMS	Continuous emission monitoring systems
CER	Certified emission reductions (generated from CDM projects)
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)
COP/MOP	COP that serves as the Meeting of the Parties to the Kyoto Protocol
DQI	Data quality indicators
DQO	Data quality objectives
EITs	Countries with Economies in Transition
ERU	Emission reduction unit (generated from Article 6 JI projects)
GHG	Greenhouse gases
IEA	International Energy Agency
IET	International Emissions Trading
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation (outlined in Article 6 of the Kyoto Protocol)
KP	Kyoto Protocol
LUCF	Land use change and forestry
N_2O	Nitrous oxide
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PAA	Parts of assigned amount
QA	Quality assurance
QC	Quality control
SO_2	Sulfur dioxide
UNFCCC	United Nations Framework Convention on Climate Change
URF	Uniform Reporting Format (form on which countries submit AIJ project-specific information to the UNFCCC)