資料６－１

IPCC グッドプラクティスガイダンス[1]（GPG 2000）における品質保証・品質管理（QA/QC）の概要

＜暫定訳＞

[1] IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories（ http://www.ipcc-nggip.iges.or.jp/public/gp/english/ ）

１． QA/QC システムの要素

QA/QC(Quality Assurance/Quality Control：品質保証/品質管理)システムは、インベントリの透明性、一貫性、比較可能性、完全性、信頼性を向上させるために必要とされる仕組みである。

インベントリの QA/QC システムの策定において考慮しなければならない主な要素は以下の通りである。

- QA/QC 計画
- QA/QC 活動(QA/QC 手続の実施・文書化)の調整に責任を負うインベントリ作成機関
- 一般的 QC 手続（Tier 1）
- 排出源カテゴリー別 QC 手続（Tier ２）
- QA レビュー手続
- 報告・文書化・保存手続

Tier ２ QC 手続きにおいては、QA/QC システムの目的から、Tier １のすべての手続と排出源カテゴリー別の QC 活動を行う。

２． QA/QC 計画

QA/QC 計画は、QA/QC システムの基本要素であり、それを策定することが適切である。一般的に、計画は QA/QC 活動の概要を記述し、インベントリ作成が毎年その最初の策定から最終報告まで準拠するタイムフレームを含まなければならない。また、計画には、全排出源カテゴリーを検証するための手続やスケジュールの概要が含まれなければならない。

QA/QC 計画は、QA/QC 活動を組織化・計画・実施するための内部文書である。一度策定されれば、その後のインベントリ作成において参照・使用され、必要に応じて改訂されるようにする。この計画は、外部レビューでも適用されなければならない。

ISO 9000 は温室効果ガスインベントリに対して設計されたものではないが、QA/QC 計画を策定し、実施する際に、ISO 9000 シリーズを含む ISO の基準やガイドラインを参照することは有用である。QA/QC 活動のシステム的に推進するために適用している国もある。

３． QA 手続

QA 手続の際に、基本的な専門家評価を Tier 1 とし、より詳細な専門家評価もしくは監査ないしはその両方を Tier 2 として追加的に行わなければならない。

（専門家評価（Expert Peer Review））

専門家評価は、関連する技術領域における専門家による計算・仮定のレビューによって行われる。この手続は、一般的に方法および結果に関連する文書のレビューを伴うが、監査において行われるようなデータや出典の厳格な証明は必要とされない。公式なステイクホルダーや一般市民によるレビューメカニズムが存在する場合には、専門家評価を補完するものとすることはできるが、代替することはできない。

専門家評価には、標準的ツールやメカニズムはなく、ケースバイケースで行われる。不確実性が高い場合、専門家評価によって推定を向上させる、または少なくとも不確実性をより適切に定量化させる情報が提供される。効果的な専門家評価には、排出源毎に特に重要な業界団体を同定し、連絡をとることが効果的な専門家評価につながることも多いと考えられる。専門家の参加は、インベントリ作成プロセス初期から行われるのが望ましい。関連する専門家を方法論やデータ取得の策定・レビューに関わらせるのが良い慣行（グッド・プラクティス）である。

専門家評価結果およびこれに対するインベントリ作成機関の対応は、インベントリ最終版が広く受け入れられるために重要であり、全専門家評価は適切に文書化されなければならない。

（監査（Audit））

インベントリ作成の良い慣行（グッド・プラクティス）として、監査を、インベントリ作成機関がどの程度適切に QC 計画に示された最低限の QC 規定に準拠したかを評価するために用いる場合もあると考えられる。その場合は、監査人は、できる限りインベントリ作成機関から独立していることが重要である。監査は、インベントリ作成時、インベントリ作成後または過年度のインベントリに対して実施される。監査は、新たな排出量算定方法が採用されたり、既存の方法に大きな変更があったりした場合に特に有効である。インベントリ作成機関が監査スケジュールを作成するのが望ましい。表 1（Tier 1 一般的なインベントリ QC 手続）に示される QC ステップが実施され、排出源別 QC 手続が QC 計画に準拠しているかを検証するのに使用することができる。

４． 一般的 QC 手続（Tier 1）

一般的 QC 手続きは、すべての排出源カテゴリーに共通する処理、対応、文書化、保存、報告の各手続に焦点が当てられている。

表1　Tier 1　一般的レベルのインベントリ QC 手続

QC 活動	手　続
活動量および排出係数の選択のための仮定・基準が文書化されているかのチェック	• 排出源カテゴリーに関する情報により活動量および排出係数をクロスチェックし、これらが適切に記録・保存されているかを確かめる。
データ入力および参照の際の転記エラーのチェック	• 内部文書化において分類データ参照が適切に引用されているかを確かめる。 • 転記エラーについて、各排出源カテゴリーからの入力データのサンプル（算定に使用される測定方法またはパラメータ）をクロスチェックする。
排出が正確に算定されているかのチェック	• 排出量算定の代表的サンプルを再現する。 • 正確性を相対的に判断するために、簡易算定を用いて複雑なモデル計算を選択的に再現する。
パラメータおよび排出単位が正確に記録され、適切な換算係数が用いられているかのチェック	• 算定シートに単位が適切に表記されているかをチェックする。 • 算定の最初から最後まで単位が正確に使用されているかをチェックする。 • 換算係数が正確かをチェックする。 • 時間的･空間的調整係数が正確に使用されているかをチェックする。
データベースファイルの完全性のチェック	• 適切なデータ処理ステップがデータベースに正確に表現されているかを確認する。 • データの関連性が正確にデータベースに表現されているかを確認する。 • データフィールドが適切に表記され、その設計仕様が適切かを確認する。 • データベース構造、モデル構造および実行の適切な文書化が保存されているかを確認する。
排出源カテゴリー間のデータにおける一貫性のチェック	• 複数の排出源カテゴリーに共通なパラメータ（活動量、定数など）を識別し、排出算定においてパラメータを適用する値に一貫性があるかを確認する。
処理ステップ間のインベントリデータの動きが正確かどうかのチェック	• 総括表を作成する際に、排出量データが正確に統合されていることをチェックする。 • 排出データがさまざまな算出過程の途中段階で正確に転記されているかどうかをチェックする。
排出および吸収における不確実性が正確に推計・算定されているかのチェック	• 不確実性の推計に対して専門家の判断を行う個人の能力が適切かをチェックする。 • 適格性、仮定および専門家の判断が記録されているかをチェックする。不確実性の算定が完了されており、正確に計算されているかをチェックする。 • 必要であれば、エラー計算またはモンテカルロ分析に用いられる確率分布の小サンプル抽出を繰り返し行う。
内部文書化のレビュ	• 推計を支援し、排出および不確実推計の再現を可能にする詳細な内

ー	部文書化が行われているかをチェックする。 • 詳細なレビューを促進するために、インベントリデータ、参考資料およびインベントリ記録が保存・保管されているかをチェックする。 • インベントリ作成に関与している外部組織のデータ保存の整理の完全性をチェックする。
再計算が必要となる方法およびデータの変更のチェック	• 各排出源の時系列の入力データにおける時間列の一貫性をチェックする。 • 時系列全般にわたって使用されるアルゴリズムおよび方法論における一貫性をチェックする。
完全性のチェック	• 全ての排出源カテゴリーおよび適切な基準年から最新のインベントリの期間までの全ての年次についての推計が報告されているかを確認する。 • 不完全な排出源カテゴリーの排出推計をもたらす既知のデータギャップが文書化されているかをチェックする。
過去の算定結果との比較	• 排出源カテゴリー毎に、最新のインベントリの算定結果が以前のものと比較されなければならない。想定されている傾向から重大な変化・乖離がある場合、推計を再チェックし、どんな差異に対しても説明をつけなければならない。

５．排出源カテゴリーの QC 手続（Tier２）

一般的 QC 手続と異なり、排出源カテゴリーの QC 手続は、個々の排出源カテゴリーで使用される特有のデータのためのものであり、排出源カテゴリー、入手可能なデータの種類および排出に関連するパラメータについての知識が必要である。

また、Tier2 の排出源カテゴリーの QC 活動が、Tier1 の中で行われる一般的 QC（すなわち表 1 にあげられた QC チェックを含む）に追加されるものであることに注意しなければならない。排出源カテゴリー特有の手法は、主要排出源(グッドプラクティスガイダンス第７章「方法の選択および再計算」参照)および方法やデータの大きな改訂が行われてきた排出源カテゴリーに焦点をあてながら、ケースバイケースで適用される。国内インベントリを編集する際に、インベントリ機関が Tier２の QC 手続を活用することは推奨（good practice）されるべきである。排出源カテゴリー特有の Tier２QC 手続の適用事例は、グッドプラクティスガイダンスのエネルギー、農業、工業プロセスおよび廃棄物の各章(第２章～５章)に記述がある。

排出源カテゴリーの QC 活動には以下のような活動がある。

- 排出データの QC
- 活動量の QC
- 不確実性評価の QC

最初の２つの活動は、ある特定の排出源カテゴリーの排出量を算出するためのデータの

種類に関わるものであり、不確実性評価の QC は、排出推計の不確実性決定に関わる活動を対象とする。

インベントリ機関によって実施されるべき実際の QC 手続は、当該排出源カテゴリーの排出推計に用いられた手法がどのようなものかによって異なる。外部機関によって算定がなされている場合は、インベントリ機関は審査の過程において QA/QC 計画の一環として外部機関の QC 活動を参照することができる。外部機関によって行われている活動が QA/QC 計画で要求されている最低限の要件に合致しているとインベントリ機関が認めるならば、重複して QC 活動を行う必要はない。

５．１　排出データの QC

以下の各項では、IPCC デフォルト排出係数、各国独自の排出係数および個別サイトの排出測定に関する QC 手続き、および排出量比較手続きについて記載する。インベントリ機関は、実際にどの程度の QC 活動を実施するかを決定するに際して、グッドプラクティスガイダンス 8.2 項「QA/QC システムの構築における実際的な考慮事項（practical consideration）」に配慮しなければならない。

５．１．１　IPCC デフォルト排出係数

IPCC デフォルト排出係数を使用する場合には、IPPC デフォルト排出係数の国内環境への適用可能性について、インベントリ機関が評価を行うことが推奨される。それは、国内条件と IPCC デフォルト排出係数算定の根拠となっている条件を比較検討するなどして評価を行うが、その際 IPCC デフォルト排出係数の根拠となっている情報が不十分であれば、インベントリ機関は、IPCC デフォルト排出係数に基づく国別排出推計の不確実性を評価するにあたって、それも考慮に入れる必要がある。

また、主要排出源に関しては、国内環境の状況を十分に表わすと考えられる排出係数を得るための選択肢も考えておく必要がある。補完的作業として、IPCC デフォルト排出係数が当該国の実際の排出源カテゴリーについて代表性を有しているかを判断するために、国内サイトあるいは施設レベルの排出係数との比較を行うことも推奨される。

５．１．２　各国独自の排出係数

各国独自の排出係数の QC は、以下の２つのステップを経ることが適切である。

第一ステップは、排出係数策定に使用されるデータの QC チェックである。排出係数およびその策定の間に行われた QA/QC の適切性の評価を行う。排出係数がサイト固有のものまたは排出源レベルの試験に基づいている場合は、インベントリ機関はその測定プログラ

ムが適切な QC 手続を踏んでいるかのチェックを行うべきである。特に、各国独自の排出係数の策定にあたっては、二次的データが使用されている場合が多いので、オリジナルデータの作成にあたって行われた QC 手続が表 1 に概説した適用可能な QC 手続きと矛盾しないか、二次的データの限界が特定され文書化されているかについて判断する必要がある。これらが適切でないと判断された場合には、インベントリ機関は、その二次的データをベースとする排出推計の不確実性について再度審査をしなければならない。

第二ステップは、各国独自の排出係数および国内的条件と、関連する IPCC デフォルト排出係数とその基礎となっている研究の特性との比較である。IPCC デフォルト排出係数が示している「平均的」排出源カテゴリーと各国独自の排出係数の排出源カテゴリーの類似性と相違点を明らかにし、各国独自の排出係数が合理的か否かを判断する。各国独自の排出係数とデフォルト排出係数の大きな違いについては、説明され文書化されるべきである。

補完的ステップとして、サイト特有の係数あるいは施設レベルでの係数が入手可能であれば、それらと各国独自の排出係数との比較がある。この種の比較は、各国独自の排出係数の妥当性とその代表性の両方の指標を提供する。

５．１．３　排出量の実測

ある排出源カテゴリーからの排出は、以下の実測手法を用いることが可能である。

- 「施設からのサンプル排出測定手法」これは、その特定のサイトあるいはカテゴリー全体を代表する排出係数の開発に使用されうる
- 継続的排出モニタリング（Continuous Emissiions Monitoring: CEM）データは、特定のプロセスからの年間の排出量推計を集計するのに使用できる。CEM は、ある特定の施設のプロセスに関するインベントリ機関を通じた数量的排出データの一式を提供し、プロセスパラメータに補正したり、排出係数のような変数を入力しなくてもよい。

実測データがどのように使用されようとも、インベントリ機関は QC 活動の一環としてそのプロセスと手法を評価しなければならない。標準的測定手法を使用することにより、実際のデータとデータの統計的特性の知見との整合性が図られる。標準的手法が使用できない場合には、国家的に、あるいは ISO10012 のように国際的に認知されている基準が測定に使われているか、およびその測定装置が基準に合っており適切に維持されているかを確認すべきである。

５．１．４　排出量の比較

各排出源カテゴリーからの排出を、以前に同じ排出源カテゴリーから提供された排出と比較したり、あるいは過去の排出傾向や後述の参照計算と比較するのが、標準的な QC 活動である。こうした比較（しばしば「現実性チェック」と呼ばれる）の目的は、算出された値がそれほど非現実的なものでなく、合理的範囲内のものであることを裏付けることであり、不合理に見える場合には、インベントリプロセスが最終段階に進む前に排出係数および活動量の再評価を行うことができる。

排出量比較の最初のステップは、入手可能な過去数年間のインベントリデータを用いた一貫性と完全性のチェックである。ほとんどの排出源カテゴリーからの排出レベルは、活動量の変化も排出係数の変化も通常ゆるやかで、年ごとに突然に変化するものではなく、年間の排出量の変化は 10%未満である。したがって、過去と比較して著しい排出量の変化は、入力あるいは計算間違いの可能性を示唆している。併せて、一部の排出源カテゴリーの重要な下位区分の排出源カテゴリーにおける排出レベルの年間の増減量の変化をチェックすることも推奨される。前年のインベントリと比較して 10%以上の変化を示している全ての排出源カテゴリーあるいはサブ排出源カテゴリーについては、その排出推計をチェックすることが推奨される。

（桁数のチェック）

桁数のチェックは、主要な計算間違いや主要な排出源カテゴリーおよびサブカテゴリの漏れを見つけ出すためのものである。チェック方法は、算定がボトムアップかボトムダウン方式のいずれを使用したかによって、異なってくる。チェックによって、重要な違いが発見されると、さらに排出源カテゴリーの QC 手法を用いて、以下の事項についてチェックが行われる。

- 個々の工場の推計値のいずれかに関連して誤りがあるか（たとえば、極端な外れ値は不合理な排出量が原因となっている可能性がある）。
- 個々の工場の個別の排出係数は、相互にかなり異なっているか。
- 個々の工場の生産率は、公表ベースの国レベルの生産率と整合性を有しているか。
- その他に大きな違いを説明できる理由があるか？

（参照計算）

排出量の計算に関して実験式に依存する排出源カテゴリーについては、もう１つの比較手法である参照計算が使用されうる。このような実験式が使われる場合、最終的な算出排出レベルは、二段燃焼率にしたがい、かつエネルギーおよび質量が保存される。特定の商品（たとえば燃料あるいは HFC、PFC、SF_6 などの製品）の消費に基づく分野別活動の総計として排出量が計算される場合、その多くは、国の総生産量＋輸入－輸出±備蓄の変化という外見的消費量を使って排出量を代替的に推計できる。IPCC ガイドラインによると、化石燃料消費からの CO_2 については、燃料の種類ごとの外見的消費量に基づく参照計算が

必須である。

インベントリデータと参照計算の格差は、インベントリデータが誤りであることを必ずしも示すものではない。格差を検討する際には、参照計算自体に不確実性があることを考慮しなければならない。

５．２　活動量の QC

多くの排出源カテゴリーの評価手法は、インベントリ機関が直接作成したのではない活動量および関連する入力変数に依存している。活動量は通常、二次的データソースを使って国レベルで照合されるか、あるいはサイトや工場の職員が独自の測定に基づいて作成したサイト固有のデータから来ている。インベントリ機関は、実施する QC 活動のレベルの決定に際しては、上述の実際的な考慮事項（practical considerations）を考慮に入れるべきである。

５．２．１　国レベルの活動量

二次的データに基づく国の活動量がインベントリに使われる場合、インベントリ機関またはその被指名人は、関連する QA/QC 活動を評価し文書化することが推奨される。活動量は、もともとは温室効果ガスの排出を推計する以外の目的で作成されているものがほとんどであるため、文書化は活動量に関して特に重要である。多くの統計機関は、データの最終用途が何であるかとは無関係に、データの質を評価するための独自の手続きを有している。これらの手続きが QA/QC 計画に列挙された最低限の活動を満たしていると判断される場合は、インベントリ機関は単純に、その統計機関によって行われた QA/QC 活動を参照することができる。

二次的活動量に関連する QC レベルが、表 1 に掲げられた QC 手続きを含むどうかを、インベントリ機関が判断することは推奨されることである。さらに、インベントリ機関は、その二次的データがピアレビューを経ているかどうかを立証し、このレビューの範囲を記録することができる。二次的データに関連する QA/QC が適切だと判断される場合は、インベントリ機関は単にそのデータソースを参照し、そのデータの排出推計への適用可能性を文書化することができる。

二次的データに関連する QC が不適切であると判断される場合は、インベントリ機関は、その二次的データに関する QA/QC の構築を試みるべきである。また、二次的データに関連する QA/QC の評価の結果に照らして、排出推計の不確実性を再評価すべきでもある。インベントリ機関はさらに、データがどのように使われているか、および IPCC デフォルト値や国際的なデータセットなどの代替的データがよりよい排出推計を提供できるかどうかについて、再検討すべきである。代替的データソースが見つからない場合は、インベントリ

機関は、QA/QC に関するサマリーレポートの一環として、その二次的データ QC に関連する不適切性について文書化すべきである。

たとえば、運輸部門では、排出推計を策定するために、各国は通常、燃料使用量または走行距離のいずれかを使う。燃料使用量および乗り物が移動した km 数の国家統計は、インベントリ機関以外の機関によって作成されるのが普通である。しかし、乗り物に関するもともとの燃料使用量および km 統計を作成した機関によってどのような QC 活動が実施されたかを判断するのは、インベントリ機関の責任である。これに関連して、以下の問題を確認するとよい。

- 統計局がデータの準備をカバーする QA/QC 計画を持っているか？
- 燃料使用量または移動 km 数を推計するために、どのようなサンプリング手続きが使われたか？
- そのサンプリング手続きは最近いつ見直されたか？
- 統計機関によってデータの中に潜在的なバイアスが確認されているか？
- 統計機関はデータの不確実性を確認および文書化しているか？
- 統計局はデータの誤りを確認および文書化しているか？

国レベルの活動量は、評価される排出源カテゴリーに関する前年のデータと比較されるべきである。ほとんどの排出源カテゴリーでは、活動量は極端には増減しない傾向があるため、いずれかの年の国の活動量が例年の傾向から大きく逸脱する場合は、その活動量に誤りがないかチェックすべきである。通常の数学的なチェックで誤りが見つからない場合は、その排出源カテゴリーの特性を調査し、変化を発見し文書化することが考えられる。

可能であれば、複数の参照情報源から活動量の比較チェックが実行されるようにする。推計に関連する不確実性の高い排出源カテゴリーでは、このことが重要である。たとえば、農業の排出源カテゴリーの多くは、家畜頭数人口、耕作面積、野焼きの範囲などの活動量について政府統計に依存しているが、同様の統計は企業、大学その他の組織でも準備でき、標準の参照情報源との比較のために使用されうる。

５．２．２　サイト固有の活動量

一部の方法は、IPCC デフォルト排出係数または各国独自の排出係数と併せて使われるサイト固有の活動量に依存している。QC チェックは、誤りなのか、測定技術の違いなのか、それとも排出量、作業条件または技術の本当の違いなのかを明らかにするために、サイト間の不一致を中心に行われるべきである。

サイトレベルの活動量の誤りを発見するためにはいろいろな QC チェックが使える。インベントリ機関は、個々のサイトでの活動量の測定に認定された国の又は国際的な基準が使われているかどうかをはっきりさせるべきである。認定された基準に従って測定が行わ

れており、かつ QA/QC プロセスが行われている場合、インベントリ機関は、そのサイトでの QA/QC プロセスはインベントリの QA/QC 計画に基づいて受容できるものであり、少なくとも Tier1 の活動を含んでいると考えるべきであり、そのサイトで使われている受容できる QA/QC 手続きを直接参照できる。標準的方法を使わずに測定が行われ、QA/QC が受容できる基準に満たない場合は、これらの活動量の使用を慎重に評価し、不確実性を再検討し、必要条件を文書化すべきである。

種々の参照情報源からの活動量の比較は、活動量 QC を拡大するためにも使用できる。もし異常値が識別されたら、それがサイトの特徴による違いであると説明できるか、あるいは報告された活動に誤りがあるかが調査されるべきである。

サイト固有の活動量チェックは、製品の使用に基づく方法にも適用できる。たとえば、電子機器の使用に伴う SF_6 排出量の算定方法は、ガスの貿易収支、リサイクル向けのガス販売量、サイト（機器の外部）におけるガス貯蔵量、処理損失、維持管理のための補給、機器システムの保有容量に依存している。この収支バランスシステムは、その機器が設置されている個々の施設ごとに適用されるべきである。国全体の活動の QC チェックは、同様の収支バランス手続きを国ベースで行うことによってできる。

ボトムアップおよびトップダウンによる収支バランス分析の結果は合致しているはずで、大きい違いがある場合は説明が必要である。同様の収支分析テクニックは、消費および排出をチェックするために、ガスの使用に基づくその他のカテゴリー（たとえばオゾン分解物質の代替品）についても QC チェックとして利用できる。

５．３　不確実性推計の QC

QC は、排出推計に関連した不確実性の計算または推計をする際にも行われるべきである。

インベントリ不確実性推計の推奨される手続きは、グッドプラクティスガイダンス 6 章に説明されているが、排出源レベルでの不確実性の計算に依存しており、その計算はその後インベントリ全体のサマリーレベルに組み合わされる。方法のうちのいくつかは、排出係数または活動量に関連した測定データの使用に依存している。測定データがない場合の不確実性推計は、専門家の判断に依存することになる。

計算が正しく、十分な文書があることを確認するために、不確実性推計に QC 手続が適用されることが推奨される。不確実性推計が基づく前提条件は、排出源カテゴリーごとに文書化されるべきである。専門家の判断を伴う不確実性推計については、専門家の資格要件、および専門家の判断を引き出すプロセスについても、チェックされ文書化されるべきである。6 章に不確実性に関する専門家の判断を文書化する方法についての助言がある[2]。

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[2] 不確実性評価の方法に関する要約は「京都議定書第５条１項に基づく温室効果ガス排出量・吸収量推計のための国内制度指針」の概要を参照。
http://www-gio.nies.go.jp/library_j/lib-j/db-j/H14GHGsanntei/sokatsu_02.pdf

＜参考＞

8

QUALITY ASSURANCE AND QUALITY CONTROL

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8.1 INTRODUCTION

An important goal of IPCC *good practice guidance* is to support the development of national greenhouse gas inventories that can be readily assessed in terms of quality and completeness. It is *good practice* to implement quality assurance and quality control (QA/QC) procedures in the development of national greenhouse gas inventories to accomplish this goal.

This guidance establishes *good practice* consistent with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*IPCC Guidelines*). The QA/QC *good practice guidance* outlined here reflects practicality, acceptability, cost-effectiveness, existing experience, and the potential for application on a world-wide basis. A QA/QC programme contributes to the objectives of *good practice guidance*, namely to improve transparency, consistency, comparability, completeness, and confidence in national inventories of emissions estimates.

The outcomes of the QA/QC process may result in a reassessment of inventory or source category uncertainty estimates. For example, if data quality is found to be lower than previously thought and this situation cannot be rectified in the timeframe of the current inventory, the uncertainty estimates ought to be re-evaluated.

The terms 'quality control' and 'quality assurance' are often used incorrectly. The definitions of QC and QA in Box 8.1 will be used for the purposes of *good practice guidance*.

BOX 8.1

DEFINITION OF QA/QC

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

(i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness;

(ii) Identify and address errors and omissions;

(iii) Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source categories, activity and emission factor data, and methods.

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, should be performed upon a finalised inventory following the implementation of QC procedures. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme.

Before implementing QA/QC activities, it is necessary to determine which techniques should be used, and where and when they will be applied. There are technical and practical considerations in making these decisions. The technical considerations related to the various QA/QC techniques are discussed in general in this chapter, and specific applications to source categories are described in the source category-specific *good practice guidance* in Chapters 2 to 5. The practical considerations involve assessing national circumstances such as available resources and expertise and the particular characteristics of the inventory. The level of QA/QC activities should be compatible with the methods or tiers used to estimate emissions for particular source categories. In addition, resources should be focused on priority areas, such as the *key source categories* (as described in Chapter 7,

Methodological Choice and Recalculation, 7.2, Determining National Key Source Categories) and source categories where changes have occurred in methods or data acquisition since the last inventory compilation.

8.2 PRACTICAL CONSIDERATIONS IN DEVELOPING QA/QC SYSTEMS

Implementing QA/QC procedures requires resources, expertise and time. In developing any QA/QC system, it is expected that judgements will need to be made on the following:

- Resources allocated to QC for different source categories and the compilation process;
- Time allocated to conduct the checks and reviews of emissions estimates;
- Availability and access to information on activity data and emission factors, including data quality;
- Procedures to ensure confidentiality of inventory and source category information, when required;
- Requirements for archiving information;
- Frequency of QA/QC checks on different parts of the inventory;
- The level of QC appropriate for each source category;
- Whether increased effort on QC will result in improved emissions estimates and reduced uncertainties;
- Whether sufficient expertise is available to conduct the checks and reviews.

In practice, the QA/QC system is only part of the inventory development process and inventory agencies do not have unlimited resources. Quality control requirements, improved accuracy and reduced uncertainty need to be balanced against requirements for timeliness and cost effectiveness. A *good practice* system seeks to achieve that balance and to enable continuous improvement of inventory estimates.

Within the QA/QC system, *good practice* provides for greater effort for *key source categories* and for those source categories where data and methodological changes have recently occurred, than for other source categories. It is unlikely that inventory agencies will have sufficient resources to conduct all the QA/QC procedures outlined in this chapter on all source categories. In addition, it is not necessary to conduct all of these procedures every year. For example, data collection processes conducted by national statistical agencies are not likely to change significantly from one year to the next. Once the inventory agency has identified what quality controls are in place, assessed the uncertainty of that data, and documented the details for future inventory reference, it is unnecessary to revisit this aspect of the QC procedure every year. However, it is *good practice* to check the validity of this information periodically as changes in sample size, methods of collection, or frequency of data collection may occur. The optimal frequency of such checks will depend on national circumstances.

While focusing QA/QC activities on *key source categories* will lead to the most significant improvements in the overall inventory estimates, it is *good practice* to plan to conduct at least the general procedures outlined in Section 8.6, General QC Procedures (Tier 1), on all parts of the inventory over a period of time. Some source categories may require more frequent QA/QC than others because of their significance to the total inventory estimates, contribution to trends in emissions over time or changes in data or characteristics of the source category, including the level of uncertainty. For example, if technological advancements occur in an industrial source category, it is *good practice* to conduct a thorough QC check of the data sources and the compilation process to ensure that the inventory methods remain appropriate.

It is recognised that resource requirements will be higher in the initial stages of implementing any QA/QC system than in later years. As capacity to conduct QA/QC procedures develops in the inventory agency and in other associated organisations, improvements in efficiency should be expected.

General QC procedures outlined in Table 8.1, Tier 1 General Inventory Level QC Procedures, and a peer review of the inventory estimates are considered minimal QA/QC activities for all inventory compilations. The general procedures require no additional expertise in addition to that needed to develop the estimates and compile the inventory and should be performed on estimates developed using Tier 1 or higher tier methods for source categories. A review of the final inventory report by a person not involved in the compilation is also *good practice*, even if the inventory were compiled using only Tier 1 methods. More extensive QC and more rigorous review processes are encouraged if higher tier methods have been used. Availability of appropriate expertise may limit the degree of independence of expert reviews in some cases. The QA/QC process is intended to ensure transparency and quality.

There may be some inventory items that involve confidential information, as discussed in Chapters 2 to 5. The inventory agency should have procedures in place during a review process to ensure that reviewers respect that confidentiality.

8.3 ELEMENTS OF A QA/QC SYSTEM

The following are the major elements to be considered in the development of a QA/QC system to be implemented in tracking inventory compilation:

- An inventory agency responsible for coordinating QA/QC activities;
- A QA/QC plan;
- General QC procedures (Tier 1);
- Source category-specific QC procedures (Tier 2);
- QA review procedures;
- Reporting, documentation, and archiving procedures.

For purposes of the QA/QC system, the Tier 2 QC approach includes all procedures in Tier 1 plus additional source category-specific activities.

8.4 INVENTORY AGENCY

The inventory agency is responsible for coordinating QA/QC activities for the national inventory. The inventory agency may designate responsibilities for implementing and documenting these QA/QC procedures to other agencies or organisations. The inventory agency should ensure that other organisations involved in the preparation of the inventory are following applicable QA/QC procedures.

The inventory agency is also responsible for ensuring that the QA/QC plan is developed and implemented. It is *good practice* for the inventory agency to designate a QA/QC coordinator, who would be responsible for ensuring that the objectives of the QA/QC programme are implemented.

8.5 QA/QC PLAN

A QA/QC plan is a fundamental element of a QA/QC system, and it is *good practice* to develop one. The plan should, in general, outline QA/QC activities that will be implemented, and include a scheduled time frame that follows inventory preparation from its initial development through to final reporting in any year. It should contain an outline of the processes and schedule to review all source categories.

The QA/QC plan is an internal document to organise, plan, and implement QA/QC activities. Once developed, it can be referenced and used in subsequent inventory preparation, or modified as appropriate (i.e. when changes in processes occur or on advice of independent reviewers). This plan should be available for external review.

In developing and implementing the QA/QC plan, it may be useful to refer to the standards and guidelines published by the International Organization for Standardization (ISO), including the ISO 9000 series (see Box 8.2). Although ISO 9000 standards are not specifically designed for emissions inventories, they have been applied by some countries to help organise QA/QC activities.

BOX 8.2

ISO AS A DATA QUALITY MANAGEMENT SYSTEM

The International Organization for Standardization (ISO) series programme provides standards for data documentation and audits as part of a quality management system. Though the ISO series is not designed explicitly for emissions data development, many of the principles may be applied to ensure the production of a quality inventory. Inventory agencies may find these documents useful source material for developing QA/QC plans for greenhouse gas inventories. Some countries (e.g. the United Kingdom and the Netherlands) have already applied some elements of the ISO standards for their inventory development process and data management.

The following standards and guidelines published under the ISO series may supplement source category-specific QA/QC procedures for inventory development and provide practical guidance for ensuring data quality and a transparent reporting system.

ISO 9004-1:	General quality guidelines to implement a quality system.
ISO 9004-4:	Guidelines for implementing continuous quality improvement within the organisation, using tools and techniques based on data collection and analysis.
ISO 10005:	Guidance on how to prepare quality plans for the control of specific projects.
ISO 10011-1:	Guidelines for auditing a quality system.
ISO 10011-2:	Guidance on the qualification criteria for quality systems auditors.
ISO 10011-3:	Guidelines for managing quality system audit programmes.
ISO 10012:	Guidelines on calibration systems and statistical controls to ensure that measurements are made with the intended accuracy.
ISO 10013:	Guidelines for developing quality manuals to meet specific needs.

Source: http://www.iso.ch/

8.6 GENERAL QC PROCEDURES (TIER 1)

The focus of general QC techniques is on the processing, handling, documenting, archiving and reporting procedures that are common to all the inventory source categories. Table 8.1, Tier 1 General Inventory Level QC Procedures, lists the general QC checks that the inventory agency should use routinely throughout the preparation of the annual inventory. Most of the checks shown in Table 8.1 could be performed by cross-checks, recalculation, or through visual inspections. The results of these QC activities and procedures should be documented as set out in Section 8.10.1, Internal Documentation and Archiving, below. If checks are performed electronically, these systems should be periodically reviewed to ensure the integrity of the checking function.

It will not be possible to check all aspects of inventory input data, parameters and calculations every year. Checks may be performed on selected sets of data and processes, such that identified *key source categories* are considered every year. Checks on other source categories may be conducted less frequently. However, a sample of data and calculations from every sector should be included in the QC process each year to ensure that all sectors are addressed on an ongoing basis. In establishing criteria and processes for selecting the sample data sets and processes, it is *good practice* for the inventory agency to plan to undertake QC checks on all parts of the inventory over an appropriate period of time.

TABLE 8.1

TIER 1 GENERAL INVENTORY LEVEL QC PROCEDURES

QC Activity	Procedures
Check that assumptions and criteria for the selection of activity data and emission factors are documented.	• Cross-check descriptions of activity data and emission factors with information on source categories and ensure that these are properly recorded and archived.
Check for transcription errors in data input and reference	• Confirm that bibliographical data references are properly cited in the internal documentation. • Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.
Check that emissions are calculated correctly.	• Reproduce a representative sample of emissions calculations. • Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.
Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used.	• Check that units are properly labelled in calculation sheets. • Check that units are correctly carried through from beginning to end of calculations. • Check that conversion factors are correct. • Check that temporal and spatial adjustment factors are used correctly.
Check the integrity of database files.	• Confirm that the appropriate data processing steps are correctly represented in the database. • Confirm that data relationships are correctly represented in the database. • Ensure that data fields are properly labelled and have the correct design specifications. • Ensure that adequate documentation of database and model structure and operation are archived.
Check for consistency in data between source categories.	• Identify parameters (e.g. activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emissions calculations.
Check that the movement of inventory data among processing steps is correct.	• Check that emissions data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries. • Check that emissions data are correctly transcribed between different intermediate products.

TABLE 8.1 (CONTINUED)

TIER 1 GENERAL INVENTORY LEVEL QC PROCEDURES

QC Activity	Procedures
Check that uncertainties in emissions and removals are estimated or calculated correctly.	• Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate. • Check that qualifications, assumptions and expert judgements are recorded. Check that calculated uncertainties are complete and calculated correctly. • If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses.
Undertake review of internal documentation.	• Check that there is detailed internal documentation to support the estimates and enable duplication of the emission and uncertainty estimates. • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review. • Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.
Check methodological and data changes resulting in re-calculations.	• Check for temporal consistency in time series input data for each source category. • Check for consistency in the algorithm/method used for calculations throughout the time series.
Undertake completeness checks.	• Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory. • Check that known data gaps that result in incomplete source category emissions estimates are documented.
Compare estimates to previous estimates.	• For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from expected trends, re-check estimates and explain any difference.

The checks in Table 8.1, should be applied irrespective of the type of data used to develop the inventory estimates and are equally applicable to source categories where default values or national data are used as the basis for the estimates.

In some cases, emissions estimates are prepared for the inventory agency by outside consultants or agencies. The inventory agency should ensure that the QC checks listed in Table 8.1, Tier 1 General Inventory Level QC Procedure, are communicated to the consultants/agencies. This will assist in making sure that QC procedures are performed and recorded by the consultant or outside agency. The inventory agency should review these QA/QC activities. In cases where official national statistics are relied upon – primarily for activity data – QC procedures may already have been implemented on these national data. However, it is *good practice* for the inventory agency to confirm that national statistical agencies have implemented adequate QC procedures equivalent to those in Table 8.1.

Due to the quantity of data that needs to be checked for some source categories, automated checks are encouraged where possible. For example, one of the most common QC activities involves checking that data keyed into a computer database are correct. A QC procedure could be set up to use an automated range check (based on the range of expected values of the input data from the original reference) for the input values as recorded in the database. A combination of manual and automated checks may constitute the most effective procedures in checking large quantities of input data.

8.7 SOURCE CATERGORY-SPECIFIC QC PROCEDURES (TIER 2)

In contrast to general inventory QC techniques, source category-specific QC procedures are directed at specific types of data used in the methods for individual source categories and require knowledge of the emission source category, the types of data available and the parameters associated with emissions.

It is important to note that Tier 2 source category-specific QC activities are in addition to the general QC conducted as part of Tier 1 (i.e. include QC checks listed in Table 8.1). The source category-specific measures are applied on a case-by-case basis focusing on *key source categories* (see Chapter 7, Methodological Choice and Recalculation) and on source categories where significant methodological and data revisions have taken place. It is *good practice* that inventory agencies applying higher tier methods in compiling national inventories utilise Tier 2 QC procedures. Specific applications of source category-specific Tier 2 QC procedures are provided in the energy, agriculture, industrial processes and waste chapters of this report (Chapters 2 to 5).

Source category-specific QC activities include the following:

- Emission data QC;
- Activity data QC;
- QC of uncertainty estimates.

The first two activities relate to the types of data used to prepare the emissions estimates for a given source category. QC of uncertainty estimates covers activities associated with determining uncertainties in emissions estimates (for more information on the determination of these uncertainties, see Chapter 6, Quantifying Uncertainties in Practice).

The actual QC procedures that need to be implemented by the inventory agency will depend on the method used to estimate the emissions for a given source category. If estimates are developed by outside agencies, the inventory agency may, upon review, reference the QC activities of the outside agency as part of the QA/QC plan. There is no need to duplicate QC activities if the inventory agency is satisfied that the QC activities performed by the outside agency meet the minimum requirements of the QA/QC plan.

8.7.1 Emissions data QC

The following sections describe QC checks on IPCC default factors, country-specific emission factors, and direct emission measurements from individual sites (used either as the basis for a site-specific emission factor or directly for an emissions estimate). Emission comparison procedures are described in Section 8.7.1.4, Emission Comparisons. Inventory agencies should take into account the practical considerations discussed in Section 8.2, Practical Considerations in Developing QA/QC Systems, when determining what level of QC activities to undertake.

8.7.1.1 IPCC DEFAULT EMISSION FACTORS

Where IPCC default emission factors are used, it is *good practice* for the inventory agency to assess the applicability of these factors to national circumstances. This assessment may include an evaluation of national conditions compared to the context of the studies upon which the IPCC default factors were based. If there is insufficient information on the context of the IPCC default factors, the inventory agency should take account of this in assessing the uncertainty of the national emissions estimates based on the IPCC default emission factors. For *key source categories*, inventory agencies should consider options for obtaining emission factors that are known to be representative of national circumstances. The results of this assessment should be documented.

If possible, IPCC default emission factor checks could be supplemented by comparisons with national site or plant-level factors to determine their representativeness relative to actual sources in the country. This supplementary check is *good practice* even if data are only available for a small percentage of sites or plants.

8.7.1.2 COUNTRY-SPECIFIC EMISSION FACTORS

Country-specific emission factors may be developed at a national or other aggregated level within the country based on prevailing technology, science, local characteristics and other criteria. These factors are not necessarily

site-specific, but are used to represent a source category or sub-source category. Two steps are necessary to ensure *good practice* emission factor QC for country-specific factors.

The first is to perform QC checks on the data used to develop the emission factors. The adequacy of the emission factors and the QA/QC performed during their development should be assessed. If emission factors were developed based on site-specific or source-level testing, then the inventory agency should check if the measurement programme included appropriate QC procedures.

Frequently, country-specific emission factors will be based on secondary data sources, such as published studies or other literature.[1] In these cases, the inventory agency could attempt to determine whether the QC activities conducted during the original preparation of the data are consistent with the applicable QC procedures outlined in Table 8.1 and whether any limitations of the secondary data have been identified and documented. The inventory agency could also attempt to establish whether the secondary data have undergone peer review and record the scope of such a review.

If it is determined that the QA/QC associated with the secondary data is adequate, then the inventory agency can simply reference the data source for QC documentation and document the applicability of the data for use in emissions estimates.

If it is determined that the QA/QC associated with the secondary data is inadequate, then the inventory agency should attempt to have QA/QC checks on the secondary data established. It should also reassess the uncertainty of any emissions estimates derived from the secondary data. The inventory agency may also reconsider how the data are used and whether any alternative data, (including IPCC default values) may provide a better estimate of emissions from this source category.

Second, country-specific factors and circumstances should be compared with relevant IPCC default factors and the characteristics of the studies on which the default factors are based. The intent of this comparison is to determine whether country-specific factors are reasonable, given similarities or differences between the national source category and the 'average' source category represented by the defaults. Large differences between country-specific factors and default factors should be explained and documented.

A supplementary step is to compare the country-specific factors with site-specific or plant-level factors if these are available. For example, if there are emission factors available for a few plants (but not enough to support a bottom-up approach) these plant-specific factors could be compared with the aggregated factor used in the inventory. This type of comparison provides an indication of both the reasonableness of the country-specific factor and its representativeness.

8.7.1.3 DIRECT EMISSION MEASUREMENTS

Emissions from a source category may be estimated using direct measurements in the following ways:

- Sample emissions measurements from a facility may be used to develop a representative emission factor for that individual site, or for the entire category (i.e. for development of a national level emission factor);
- Continuous emissions monitoring (CEM) data may be used to compile an annual estimate of emissions for a particular process. In theory, CEM can provide a complete set of quantified emissions data across the inventory period for an individual facility process, and does not have to be correlated back to a process parameter or input variable like an emission factor.

Regardless of how direct measurement data are being used, the inventory agency should review the processes and check the measurements as part of the QC activities.

Use of standard measurement methods improves the consistency of resulting data and knowledge of the statistical properties of the data. If standard reference methods for measuring specific greenhouse gas emissions (and removals) are available, inventory agencies should encourage plants to use these. If specific standard methods are not available, the inventory agency should confirm whether nationally or internationally recognised standard methods such as ISO 10012 are used for measurements and whether the measurement equipment is calibrated and maintained properly.

For example, ISO has published standards that specify procedures to quantify some of the performance characteristics of all air quality measurement methods such as bias, calibration, instability, lower detection limits, sensitivity, and upper limits of measurement (ISO, 1994). While these standards are not associated with a

[1] Secondary data sources refer to reference sources for inventory data that are not designed for the express purpose of inventory development. Secondary data sources typically include national statistical databases, scientific literature, and other studies produced by agencies or organisations not associated with the inventory development.

reference method for a specific greenhouse gas source category, they have direct application to QC activities associated with estimations based on measured emission values.

Where direct measurement data from individual sites are in question, discussions with site managers can be useful to encourage improvement of the QA/QC practices at the sites. Also, supplementary QC activities are encouraged for bottom-up methods based on site-specific emission factors where significant uncertainty remains in the estimates. Site-specific factors can be compared between sites and also to IPCC or national level defaults. Significant differences between sites or between a particular site and the IPCC defaults should elicit further review and checks on calculations. Large differences should be explained and documented.

8.7.1.4 EMISSION COMPARISONS

It is standard QC practice to compare emissions from each source category with emissions previously provided from the same source category or against historical trends and reference calculations as described below. The objective of these comparisons (often referred to as 'reality checks') is to ensure that the emission values are not wildly improbable or that they fall within a range that is considered reasonable. If the estimates seem unreasonable, emission checks can lead to a re-evaluation of emission factors and activity data before the inventory process has advanced to its final stages.

The first step of an emissions comparison is a consistency and completeness check using available historical inventory data for multiple years. The emission levels of most source categories do not abruptly change from year to year, as changes in both activity data and emission factors are generally gradual. In most circumstances, the change in emissions will be less than 10% per year. Thus, significant changes in emissions from previous years may indicate possible input or calculation errors. After calculating differences, the larger percentage differences (in any direction) should be flagged, by visual inspection of the list, by visual inspection of the graphical presentation of differences (e.g. in a spreadsheet) or by using a dedicated software programme that puts flags and rankings in the list of differences.

It is *good practice* to also check the annual increase or decrease of changes in emissions levels in significant sub-source categories of some source categories. Sub-source categories may show greater percentage changes than the aggregated source categories. For example, total emissions from petrol cars are not likely to change substantially on an annual basis, but emissions from sub-source categories, such as catalyst-equipped petrol cars, may show substantial changes if the market share is not in equilibrium or if the technology is changing and rapidly being adopted in the marketplace.

It is *good practice* to check the emissions estimates for all source categories or sub-source categories that show greater than 10% change in a year compared to the previous year's inventory. Source categories and sub-source categories should be ranked according to the percentage difference in emissions from the previous year.

Supplementary emission comparisons can also be performed, if appropriate, including order-of-magnitude checks and reference calculations.

ORDER-OF-MAGNITUDE CHECKS

Order of magnitude checks look for major calculation errors and exclusion of major source categories or sub-source categories. Method-based comparisons may be made depending on whether the emissions for the source category were determined using a top-down or bottom-up approach. For example, if N_2O estimates for nitric acid production were determined using a bottom-up approach (i.e. emissions estimates were determined for each individual production plant based on plant-specific data), the emissions check would consist of comparing the sum of the individual plant-level emissions to a top-down emission estimate based on national nitric acid production figures and IPCC default Tier 1 factors. If significant differences are found in the comparison, further investigation using the source category-specific QC techniques described in Section 8.7, Source Category-Specific QC Procedures (Tier 2), would be necessary to answer the following questions:

- Are there inaccuracies associated with any of the individual plant estimates (e.g. an extreme outlier may be accounting for an unreasonable quantity of emissions)?
- Are the plant-specific emission factors significantly different from each other?
- Are the plant-specific production rates consistent with published national level production rates?
- Is there any other explanation for a significant difference, such as the effect of controls, the manner in which production is reported or possibly undocumented assumptions?

This is an example of how the result of a relatively simple emission check can lead to a more intensive investigation of the representativeness of the emissions data. Knowledge of the source category is required to

isolate the parameter that is causing the difference in emissions estimates and to understand the reasons for the difference.

REFERENCE CALCULATIONS

Another emission comparison may be used for source categories that rely on empirical formulas for the calculation of emissions. Where such formulas are used, final calculated emission levels should follow stochiometric ratios and conserve energy and mass. In a number of cases where emissions are calculated as the sum of sectoral activities based on the consumption of a specific commodity (e.g. fuels or products like HFCs, PFCs or SF_6), the emissions could alternatively be estimated using apparent consumption figures: national total production + import – export ± stock changes. For CO_2 from fossil fuel combustion, a reference calculation based on apparent fuel consumption per fuel type is mandatory according to the *IPCC Guidelines*. Another example is estimating emissions from manure management. The total quantity of methane produced should not exceed the quantity that could be expected based on the carbon content of the volatile solids in the manure.

Discrepancies between inventory data and reference calculations do not necessarily imply that the inventory data are in error. It is important to consider that there may be large uncertainties associated with the reference calculations themselves when analysing discrepancies.

8.7.2 Activity data QC

The estimation methods for many source categories rely on the use of activity data and associated input variables that are not directly prepared by the inventory agency. Activity data is normally collated at a national level using secondary data sources or from site-specific data prepared by site or plant personnel from their own measurements. Inventory agencies should take into account the practical considerations discussed above when determining the level of QC activities to undertake.

8.7.2.1 NATIONAL LEVEL ACTIVITY DATA

Where national activity data from secondary data sources are used in the inventory, it is *good practice* for the inventory agency or its designees to evaluate and document the associated QA/QC activities. This is particularly important with regard to activity data, since most activity data are originally prepared for purposes other than as input to estimates of greenhouse gas emissions. Though not always readily available, many statistical organisations, for example, have their own procedures for assessing the quality of the data independently of what the end use of the data may be. If it is determined that these procedures satisfy minimum activities listed in the QA/QC plan, the inventory agency can simply reference the QA/QC activities conducted by the statistical organisation.

It is *good practice* for the inventory agency to determine if the level of QC associated with secondary activity data includes those QC procedures listed in Table 8.1. In addition, the inventory agency may establish whether the secondary data have been peer reviewed and record the scope of this review. If it is determined that the QA/QC associated with the secondary data is adequate, then the inventory agency can simply reference the data source and document the applicability of the data for use in its emissions estimates.

If it is determined that the QC associated with the secondary data is inadequate, then the inventory agency should attempt to have QA/QC checks on the secondary data established. It should also reassess the uncertainty of emissions estimates in light of the findings from its assessment of the QA/QC associated with secondary data. The inventory agency should also reconsider how the data are used and whether any alternative data, including IPCC default values and international data sets, may provide for a better estimate of emissions. If no alternative data sources are available, the inventory agency should document the inadequacies associated with the secondary data QC as part of its summary report on QA/QC (see Section 8.10.2, Reporting, for reporting guidance).

For example, in the transportation category, countries typically use either fuel usage or kilometer (km) statistics to develop emissions estimates. The national statistics on fuel usage and kms travelled by vehicles are usually prepared by a different agency from the inventory agency. However, it is the responsibility of the inventory agency to determine what QA/QC activities were implemented by the agency that prepared the original fuel usage and km statistics for vehicles. Questions that may be asked in this context are:

- Does the statistical agency have a QA/QC plan that covers the preparation of the data?
- What sampling protocol was used to estimate fuel usage or kms travelled?
- How recently was the sampling protocol reviewed?
- Has any potential bias in the data been identified by the statistical agency?

- Has the statistical agency identified and documented uncertainties in the data?
- Has the statistical agency identified and documented errors in the data?

National level activity data should be compared with previous year's data for the source category being evaluated. *Activity data* for most source categories tend to exhibit relatively consistent changes from year to year without sharp increases or decreases. If the national activity data for any year diverge greatly from the historical trend, the activity data should be checked for errors. If the general mathematical checks do not reveal errors, the characteristics of the source category could be investigated and any change identified and documented.

Where possible, a comparison check of activity data from multiple reference sources should be undertaken. This is important for source categories that have a high level of uncertainty associated with their estimates. For example, many of the agricultural source-categories rely on government statistics for activity data such as livestock populations, areas under cultivation, and the extent of prescribed burning. Similar statistics may be prepared by industry, universities, or other organisations and can be used to compare with standard reference sources. As part of the QC check, the inventory agency should ascertain whether independent data have been used to derive alternative activity data sets. In some cases, the same data are treated differently by different agencies to meet varying needs. Comparisons may need to be made at a regional level or with a subset of the national data since many alternative references for such activity data have limited scope and do not cover the entire nation.

8.7.2.2 SITE-SPECIFIC ACTIVITY DATA

Some methods rely on the use of site-specific activity data used in conjunction with IPCC default or country-specific emission factors. Site or plant personnel typically prepare these estimates of activity, often for purposes other than as inputs to emissions inventories. QC checks should focus on inconsistencies between sites to establish whether these reflect errors, different measurement techniques, or real differences in emissions, operating conditions or technology.

A variety of QC checks can be used to identify errors in site-level activity data. The inventory agency should establish whether recognised national or international standards were used in measuring activity data at the individual sites. If measurements were made according to recognised national or international standards and a QA/QC process is in place, the inventory agency should satisfy itself that the QA/QC process at the site is acceptable under the inventory QA/QC plan and at least includes Tier 1 activities. Acceptable QC procedures in use at the site may be directly referenced. If the measurements were not made using standard methods and QA/QC is not of an acceptable standard, then the use of these activity data should be carefully evaluated, uncertainty estimates reconsidered, and qualifications documented.

Comparisons of activity data from different reference sources may also be used to expand the activity data QC. For example, in estimating PFC emissions from primary aluminium smelting, many inventory agencies use smelter-specific activity data to prepare the inventory estimates. A QC check of the aggregated activity data from all aluminium smelters can be made against national production statistics for the industry. Also, production data can be compared across different sites, possibly with adjustments made for plant capacities, to evaluate the reasonableness of the production data. Similar comparisons of activity data can be made for other manufacturing-based source categories where there are published data on national production. If outliers are identified, they should be investigated to determine if the difference can be explained by the unique characteristics of the site or there is an error in the reported activity.

Site-specific activity data checks may also be applied to methods based on product usage. For example, one method for estimating SF_6 emissions from use in electrical equipment relies on an account balance of gas purchases, gas sales for recycling, the amount of gas stored on site (outside of equipment), handling losses, refills for maintenance, and the total holding capacity of the equipment system. This account balance system should be used at each facility where the equipment is in place. A QC check of overall national activity could be made by performing the same kind of account balancing procedure on a national basis. This national account balancing would consider national sales of SF_6 for use in electrical equipment, the nation-wide increase in the total handling capacity of the equipment (that may be obtained from equipment manufacturers), and the quantity of SF_6 destroyed in the country. The results of the bottom-up and top-down account balancing analyses should agree or large differences should be explained. Similar accounting techniques can be used as QC checks on other categories based on gas usage (e.g. substitutes for ozone-depleting substances) to check consumption and emissions.

8.7.3 QC of uncertainty estimates

QC should also be undertaken on calculations or estimates of uncertainty associated with emissions estimates. *Good practice* for estimating inventory uncertainties is described in Chapter 6, Quantifying Uncertainties in Practice, and relies on calculations of uncertainty at the source category level that are then combined to summary levels for the entire inventory. Some of the methods rely on the use of measured data associated with the emission factors or activity data to develop probability density functions from which uncertainty estimates can be made. In the absence of measured data, many uncertainty estimates will rely on expert judgement.

It is *good practice* for QC procedures to be applied to the uncertainty estimations to confirm that calculations are correct and that there is sufficient documentation to duplicate them. The assumptions on which uncertainty estimations have been based should be documented for each source category. Calculations of source category-specific and aggregated uncertainty estimates should be checked and any errors addressed. For uncertainty estimates involving expert judgement, the qualifications of experts should also be checked and documented, as should the process of eliciting expert judgement, including information on the data considered, literature references, assumptions made and scenarios considered. Chapter 6 contains advice on how to document expert judgements on uncertainties.

8.8 QA PROCEDURES

Good practice for QA procedures requires an objective review to assess the quality of the inventory, and also to identify areas where improvements could be made. The inventory may be reviewed as a whole or in parts. QA procedures are utilised in addition to the Tier 1 and Tier 2 QC. The objective in QA implementation is to involve reviewers that can conduct an unbiased review of the inventory. It is *good practice* to use QA reviewers that have not been involved in preparing the inventory. Preferably these reviewers would be independent experts from other agencies or a national or international expert or group not closely connected with national inventory compilation. Where third party reviewers outside the inventory agency are not available, staff from another part of the inventory agency not involved in the portion of the inventory being reviewed can also fulfil QA roles.

It is *good practice* for inventory agencies to conduct a basic expert peer review (Tier 1 QA) prior to inventory submission in order to identify potential problems and make corrections where possible. It is also *good practice* to apply this review to all source categories in the inventory. However, this will not always be practical due to timing and resource constraints. *Key source categories* should be given priority as well as source categories where significant changes in methods or data have been made. Inventory agencies may also choose to perform more extensive peer reviews or audits or both as additional (Tier 2) QA procedures within the available resources.

More specific information on QA procedures related to individual source categories is provided in the source category-specific QA/QC sections in Chapters 2 to 5.

EXPERT PEER REVIEW

Expert peer review consists of a review of calculations or assumptions by experts in relevant technical fields. This procedure is generally accomplished by reviewing the documentation associated with the methods and results, but usually does not include rigorous certification of data or references such as might be undertaken in an audit. The objective of the expert peer review is to ensure that the inventory's results, assumptions, and methods are reasonable as judged by those knowledgeable in the specific field. Expert review processes may involve technical experts and, where a country has formal stakeholder and public review mechanisms in place, these reviews can supplement but not replace expert peer review.

There are no standard tools or mechanisms for expert peer review, and its use should be considered on a case-by-case basis. If there is a high level of uncertainty associated with an emission estimate for a source category, expert peer review may provide information to improve the estimate, or at least to better quantify the uncertainty. Expert reviews may be conducted on all parts of a source category. For example, if the activity data estimates from oil and natural gas production are to be reviewed but not the emission factors, experts in the oil and gas industry could be involved in the review to provide industry expertise even if they do not have direct experience in greenhouse gas emissions estimation. Effective peer reviews often involve identifying and contacting key industrial trade organisations associated with specific source categories. It is preferable for this expert input to be sought early in the inventory development process so that the experts can participate from the start. It is *good practice* to involve relevant experts in development and review of methods and data acquisition.

The results of expert peer review, and the response of the inventory agency to those findings, may be important to widespread acceptance of the final inventory. All expert peer reviews should be well documented, preferably in a report or checklist format that shows the findings and recommendations for improvement.

AUDITS

For the purpose of *good practice* in inventory preparation, audits may be used to evaluate how effectively the inventory agency complies with the minimum QC specifications outlined in the QC plan. It is important that the auditor be independent of the inventory agency as much as possible so as to be able to provide an objective assessment of the processes and data evaluated. Audits may be conducted during the preparation of an inventory, following inventory preparation, or on a previous inventory. Audits are especially useful when new emission estimation methods are adopted, or when there are substantial changes to existing methods. It is desirable for the inventory agency to develop a schedule of audits at strategic points in the inventory development. For example, audits related to initial data collection, measurement work, transcription, calculation and documentation may be conducted. Audits can be used to verify that the QC steps identified in Table 8.1 have been implemented and that source category-specific QC procedures have been implemented according to the QC plan.

8.9 VERIFICATION OF EMISSIONS DATA

Options for inventory verification processes are described in Annex 2, Verification. Verification techniques can be applied during inventory development as well as after the inventory is compiled.

Comparisons with other independently compiled, national emissions data (if available) are a quick option to evaluate completeness, approximate emission levels and correct source category allocations. These comparisons can be made for different greenhouse gases at national, sectoral, source category, and sub-source category levels, as far as the differences in definitions enable them.

Although the inventory agency is ultimately responsible for the compilation and submission of the national greenhouse gas inventory, other independent publications on this subject may be available (e.g. from scientific literature or other institutes or agencies). These documents may provide the means for comparisons with other national estimates.

The verification process can help evaluate the uncertainty in emissions estimates, taking into account the quality and context of both the original inventory data and data used for verification purposes. Where verification techniques are used, they should be reflected in the QA/QC plan. Improvements resulting from verification should be documented, as should detailed results of the verification process.

8.10 DOCUMENTATION, ARCHIVING AND REPORTING

8.10.1 Internal documentation and archiving

As part of general QC procedures, it is *good practice* to document and archive all information required to produce the national emissions inventory estimates. This includes:

- Assumptions and criteria for selection of activity data and emission factors;
- Emission factors used, including references to the IPCC document for default factors or to published references or other documentation for emission factors used in higher tier methods;
- Activity data or sufficient information to enable activity data to be traced to the referenced source;
- Information on the uncertainty associated with activity data and emission factors;
- Rationale for choice of methods;
- Methods used, including those used to estimate uncertainty;
- Changes in data inputs or methods from previous years;
- Identification of individuals providing expert judgement for uncertainty estimates and their qualifications to do so;

- Details of electronic databases or software used in production of the inventory, including versions, operating manuals, hardware requirements and any other information required to enable their later use;
- Worksheets and interim calculations for source category estimates and aggregated estimates and any re-calculations of previous estimates;
- Final inventory report and any analysis of trends from previous years;
- QA/QC plans and outcomes of QA/QC procedures.

It is *good practice* for inventory agencies to maintain this documentation for every annual inventory produced and to provide it for review. It is *good practice* to maintain and archive this documentation in such a way that every inventory estimate can be fully documented and reproduced if necessary. Inventory agencies should ensure that records are unambiguous; for example, a reference to 'IPCC default factor' is not sufficient. A full reference to the particular document (e.g. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*) is necessary in order to identify the source of the emission factor because there may have been several updates of default factors as new information has become available.

Records of QA/QC procedures are important information to enable continuous improvement to inventory estimates. It is *good practice* for records of QA/QC activities to include the checks/audits/reviews that were performed, when they were performed, who performed them, and corrections and modifications to the inventory resulting from the QA/QC activity.

8.10.2 Reporting

It is *good practice* to report a summary of implemented QA/QC activities and key findings as a supplement to each country's national inventory. However, it is not practical or necessary to report all the internal documentation that is retained by the inventory agency. The summary should describe which activities were performed internally and what external reviews were conducted for each source category and on the entire inventory in accordance with the QA/QC plan. The key findings should describe major issues regarding quality of input data, methods, processing, or archiving and show how they were addressed or plan to be addressed in the future.

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