What do national statistical offices (NSOs) need to know about greenhouse gas (GHG) inventories?

Table of Contents

Note: A previous version of this paper was presented at the UNECE Forum that took place in FAO, Rome in October 2017. The Steering Group would like to thank everyone for its active participation. All comments made by the participants have been considered to the extent possible.

1. Introduction: Context and purpose of this paper

Overall data quality improvements - We need the best data to fight climate change most effectively. GHG inventories are instrumental to this objective and NSOs can contribute to this aim. Yet, they are not always involved or sufficiently involved. Learning more about GHG inventories can help NSOs improve cooperation with GHG inventory compilers with mutual benefits to both which should lead to quality improvements in emission inventories. Quality improvements in activity data (i.e. underpinning data used to estimate emissions in national GHG inventories) are essential to the process of emission estimation, reporting and review under UNFCCC. NSOs can be fundamental in this process, ensuring activity data availability, improvements in the quality of the data, QA/QC and verification. This becomes even more important with the Paris agreement, where all Parties will have to report GHG inventories according to common rules, including some flexibilities, which will be the basis for tracking progress towards the national determined contributions (NDCs).

NSOs in the GHG inventory system - In previous UNECE Fora, panellists discussed and broadly agreed that NSOs should be part of the National Inventory System and/or institutional arrangements for inventory preparation. The decision of how to organise the national inventory system (or institutional arrangements) is an internal matter for discussion within the national context and coordinated through the national focal points to UNFCCC. The national institutional arrangements in the current reporting and review under UNFCCC and the Kyoto Protocol started to be organised during the first decade of the 2000s and were broadly consolidated by 2008. Changes to the national system are possible and Parties have to report on any changes as part of their GHG inventory reporting. In practice, institutional changes are not that common, which is partly due to ensuring 'business continuity', particularly when the internal set-up already delivers good quality GHG inventories. Yet, the upcoming implementation of the Paris agreement opens up new opportunities for Parties regarding reporting and review and how NSOs can contribute to quality improvements in GHG inventories; e.g. as data providers, for QA/QC, verification, data sharing arrangements, etc. More involvement of NSOs in GHG inventories would thus benefit the quality of emission inventories.

UNECE Survey and results - In 2016, the UNECE Steering Group on Climate Change-related Statistics carried out a survey to collect information on countries' progress and plans in developing their statistics to inform climate policy and research. The survey also collected input as to how UNECE and the Steering Group can support countries in further enhancement of national statistics for climate change policy and analysis. The survey had a special emphasis on greenhouse gas inventories, and looked at how statistics are used in the inventories, and how cooperation and institutional arrangements support the provision of high quality data and statistics for the inventories. The survey was designed to reflect progress against the *CES Recommendations on Climate Change-related Statistics*. A previous UNECE Survey carried out in 2011 already showed that NSOs have some experience supporting GHG inventories in their countries. Based on the results from the 2016 Survey, one of the priority areas for the Steering Group is to clarify and provide guidance about key issues NSOs need to know regarding GHG inventories.

Objectives of this paper - The objectives of this technical paper are three fold:

- To clarify and provide guidance on key issues NSOs need to know regarding GHG inventories;
- To inform about and improve the understanding of the current and potential role of NSOs in GHG inventories;

- To give some insights or take-home messages regarding issues of relevance from a GHG inventory perspective that can be useful to NSOs from their perspective

2. Why do we need GHG inventories? Understanding the user need

Different uses of inventories and the current role of NSOs - There are various users and uses of GHG inventories as described in the relevant section of the 'CES Recommendations on Climate Change-related Statistics'[1]. While NSOs are usually not directly responsible for the GHG inventories, they have a crucial role to play in ensuring inventory quality through the provision of activity data. Indeed, much of the activity data needed for the GHG inventories come from official statistics and many of these data are produced as statistics in their own right by NSOs or other producers of official statistics. The 2011 UNECE survey showed that NSOs have considerable experience supporting inventory compilation. The survey showed that more than 75 per cent of NSOs (37 countries out of 48) said they were in some way involved in the work related to greenhouse gas inventories: 20 were involved in providing activity data only, 12 participated in the calculations of emissions based on activity data, 5 were responsible for most of the inventory calculations and 4 of these actually reported their countries' inventories. Most NSOs who participated in the process did so by collaborating with other institutions, such as ministries or research bodies, under the auspices of special committees or expert working groups. More information can be found in '[How national statistical offices can support greenhouse gas inventories]'[2]

GHG inventory compilers as users of statistical data - There is another perspective of user-need, i.e. GHG inventory compilers as users of statistical data collected by NSOs. It is important for NSOs to recognise that GHG inventory compilers are or could be users and that resources be available to understand and eventually fulfil this user need, as it is the case for other users of statistical data.

GHG inventories as a source for 'air emission accounts', which are often compiled by NSOs. This is highlighted in the CES recommendations: 'Closer cooperation between NSOs and the agencies responsible for greenhouse gas inventories has the potential to be mutually beneficial not only because GHG inventories rely on the data from the statistical system but also because NSOs often take the results of GHG inventories once published and adjust them to national accounts concepts to allocate emissions to industries and households. The latter is a requirement in Europe through the EU Regulation No. 691/2011 on European environmental accounts that was adopted in 2011'.

---

[1] The users of statistics with respect to GHG inventories can be classified as: the agencies responsible for greenhouse gas inventories; the inventory reviewers; and climate change analysts and other uses. Whereas the first group are mostly interested in the availability of good quality activity data, the focus of the second group is on the review and assessment of the quality of the emission estimates. The third group, climate change analysts, has become increasingly prominent in recent years. Their task is to interpret the inventory information for the policy makers, the media and the general public. This would also include one essential use of GHG inventories: that is, to be the basis for mitigation analyses and projections as well as for the monitoring of progress towards GHG mitigation/emission objectives and targets.

[2] The Task Force on Climate Change-Related Statistics and its successor, the Steering Group on Climate Change-Related Statistics affirmed that the role of NSOs should be clarified in relation to GHG inventory work. The paper attempts to outline this role by looking, inter alia, at entry points of NSOs' involvement in the national GHG inventory process, benefits of NSOs' engagement, and challenges of enhancing the role of NSOs. The paper also contains suggestions on how to increase cooperation both on national and international levels.

GHG inventories as input to policy making and tracking of progress - GHG inventories are the nuts and bolts of the MRV system and the basis for tracking national and international climate objectives. GHG inventories are also an essential input to GHG projections to monitor progress towards climate mitigation goals/targets, including NDCs in the future. GHG inventories are used to evaluate the effectiveness of policies and measures; either *ex-ante*, to estimate the potential emission savings before policies are implemented, or *ex-post*, to evaluate whether implemented policies have delivered the expected results. In sum, emission inventories are a key source of information for mitigation analyses and projections as well as for the monitoring of progress towards GHG mitigation objectives and targets. Where possible, NSOs should acquaint themselves with the political commitments made by their countries in relation to climate, as this would help bridge the gap between policy makers and the general public and raise the importance of the data used in GHG inventories.

The key objective of having GHG inventories – One should not forget that the ultimate objective of the UNFCCC is 'to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner' (article 2 of the UNFCCC). Thus, GHG inventories, (very detailed ones currently reported by Annex I Parties) are in essence meant to underpin and substantiate climate mitigation and adaptation efforts by Parties. With the future implementation of the Paris agreement the number of Parties reporting a GHG inventory will increase and should in time result in a global coverage of emissions and sinks to monitor the 2 degree target (and further on to monitor global emissions so that we do not exceed 1.5 degrees). Even though the current distinction between Annex I and non-Annex I Parties disappears, the transparency framework (article 13 of the Paris agreement) shall provide flexibility in its implementation to those developing country Parties that need it in the light of their capacities.

3. Reporting requirements related to GHG inventories

Current reporting rules - There is a significant amount of GHG-inventory-related reporting to UNFCCC, primarily for Annex I Parties, including reporting of GHG inventories under the Convention (UNFCCC), reporting of GHG inventories under the Kyoto Protocol (CP2 at the moment), and GHG inventory information as contained in Biennial Reports (for Annex I Parties), Biennial Update Reports (for non-Annex I Parties) and National Communications. In relation to Annex I GHG inventories, the objectives are explicit in the UNFCCC Reporting Guidelines, and include contributing to ensuring the transparency of emission reduction commitments[3]. These objectives are applicable to the 44 Annex I Parties to the

[3] The objectives of the UNFCCC reporting guidelines for GHG inventories are: (a) To assist Parties included in Annex I to the Convention (Annex I Parties) in meeting their commitments under Articles 4 and 12 of the Convention; (b) To contribute to ensuring the transparency of emission reduction commitments; (c) To facilitate the process of considering annual national inventories, including the preparation of technical analysis and synthesis documentation; (d) To facilitate the process of verification, technical assessment and expert review of the inventory information; (e) To assist Annex I Parties in ensuring and/or improving the quality of their annual GHG inventory submissions.

UNFCCC. In addition to being mandatory for Annex I Parties to the UNFCCC, GHG inventories improve confidence in GHG emission trends and help track progress towards emission targets.

Reporting of annual GHG inventories - The current reporting system depends on how the Party is categorized. Under the UNFCCC, Annex I Parties are required to report national GHG inventories annually using the 2006 IPCC Guidelines. For non-Annex I countries, the reporting requirements are less stringent. Non-Annex I countries are required to provide a less detailed and less frequent GHG inventory, based on the 1996 Revised IPCC guidelines (although more and more Parties use the 2006 IPCC Guidelines). Since the introduction of Biennial Update Reports (BURs) in 2011, non-Annex I countries have to report inventories to the UNFCCC every two years, although the number of BURs reported to date has been much lower than expected.

The UNFCCC Reporting Guidelines for Annex I GHG inventories are the rules governing what is to be reported, how and when. These Guidelines require each Annex I Party, by 15 April each year, to provide its annual GHG inventory covering emissions and removals of direct GHGs (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF3) from five sectors (energy; industrial processes and product use; agriculture; land use, land-use change and forestry (LULUCF); and waste), and for all years from the base year (or period) to two years before the inventory is due. Under the UNFCCC reporting guidelines on annual inventories for Annex I Parties, inventory submissions are in two parts: (a) The 'common reporting format' (CRF) tables – a series of standardized data tables containing mainly quantitative information, using the CRF Reporter software. (b) A National Inventory Report (NIR) – containing transparent information on the GHG inventory. It should include descriptions of the methodologies used in the estimations, the data sources, the institutional arrangements for the preparation of the inventory (including quality assurance and control procedures), and recalculations and changes compared with the previous inventory.

Annex I Parties should also implement and maintain *national GHG inventory arrangements* for the estimation of anthropogenic GHG emissions by sources and removals by sinks. The national inventory arrangements include all institutional, legal and procedural arrangements made within an Annex I Party for estimating emissions and removals of GHGs, and for reporting and archiving inventory information.

Future reporting rules - The Paris agreement builds upon the Convention and its main objective is to strengthen the global response to keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius[4]. Central to these objectives is that the Agreement also provides for 'enhanced transparency of action and support' through a more robust transparency framework[5] It is important to

[4] The Paris agreement also aims to strengthen the ability of countries to deal with climate-change impacts. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. On 5 October 2016, the threshold for entry into force of the Paris Agreement was achieved. The Paris Agreement entered into force on 4 November 2016.

[5] The Paris Agreement relies on a robust transparency and accounting system to provide clarity on action and support by Parties, with flexibility for their differing capabilities of Parties. In addition to reporting information on mitigation, adaptation and support, the Agreement requires that the information submitted by each Party undergoes international review. The Agreement also includes a mechanism that will facilitate implementation and promote compliance in a non-adversarial and non-punitive manner, and will report annually to the CMA. The Paris Agreement also requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This

flag that signatories to the Paris agreement shall report GHG inventories based on common modalities, procedures and guidelines (MPGs)[6], which are being currently negotiated, although allowing flexibility in the implementation to those developing country Parties that need it in the light of their capacities. The MPGs are essential for tracking progress towards' Parties National Determined Contributions (NDCs) and the 2-degree target.

In relation to the future reporting on GHG inventories under the Paris agreement, each Party shall regularly provide the following information:

(a) A national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;

(b) Information necessary to track progress made in implementing and achieving its nationally determined contribution.

In other words, all countries will have to estimate emissions, compile a GHG inventory and report it to UNFCCC and this reporting should be based on common rules. The way the common rules (modalities, procedures and guidelines) will look like is yet unclear as there is an ongoing negotiation process that started in 2017 and should end by 2018 at the COP in Katovice (Poland). However, GHG inventories will become a mandatory requirement for all Parties, although the enhanced transparency framework of the Paris agreement allows for some flexibility in its implementation to those developing country Parties that need it in the light of their capacities.

4. Methodological guidance to GHG inventory compilation

The main methodological reference for the compilation of GHG emission inventories is the 2006 IPCC Guidelines, which are mandatory for the reporting of GHG inventories by Annex I Parties. The revised 1996 IPCC Guidelines and the 2000 Good Practice Guidance are still used in BURs and NCs by some non-Annex I Parties, although more and more Parties are moving or planning to move towards the 2006 IPCC guidelines.

The IPCC Guidelines are organized across sectors (energy, industrial processes, agriculture, LULUCF and waste in volumes 2-5) as well as the general cross cutting chapters. The latter chapters in volume 1 could be particularly relevant for NSOs as they deal with the general guidance and reporting. They include:

includes requirements that all Parties report regularly on their emissions and on their implementation efforts. In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stock-take every 5 years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties http://bigpicture.unfccc.int/#content-the-paris-agreement

[6] According to article 13.13 of the Paris Agreement, the Conference of the Parties (COP) shall, building on experience related to transparency under the Convention, adopt common modalities, procedures and guidelines (MPGs), for the transparency of action and support. The MPGs are to be adopted by the COP in 2018.

1 Introduction

2 Approaches to Data Collection - Collection of data is a fundamental part of inventory preparation. Chapter 2 of Volume 1 provides guidance on initiating and maintaining a data collection program. It covers evaluating existing sources of data, and planning new emission measurements and surveys, extensive reference is made to guidance provided by other organisations.

3 Uncertainties - Estimates of uncertainty are needed for all relevant source and sink categories, greenhouse gases, inventory totals as a whole, and their trends. Chapter 3, Uncertainties, provides practical guidance for estimating and combining uncertainties, along with a discussion of the conceptual underpinnings of inventory uncertainty.

4 Methodological Choice and Identification of Key Categories[7] - Good practice guidance on how to identify key categories of emissions and removals is provided in Chapter 4, Methodological Choice and Identification of Key Categories. The key category concept is used, together with the decision trees in Volumes 2-5, to guide users in their methodological choice for each category.

5 Time Series Consistency - Ensuring the time series consistency of inventory estimates is essential for establishing confidence in reported inventory trends. Chapter 5, Time Series Consistency, provides methods for ensuring time-series consistency in cases where it is not possible to use the same method and/or data over the entire period. This chapter also provides good practice guidance on when to recalculate estimates for previous years and methods for accounting for changes in emissions and removals over time.

[7] According to the IPCC Guidelines, a key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals.

6 Quality Assurance /Quality Control and Verification - A QA/QC system is an important part of inventory development. Chapter 6, QA/QC and Verification, describes the general QA/QC aspects to consider when compiling an inventory of emissions and removals. Good practice guidance on sector specific quality control checks are addressed in Volumes 2-5. Chapter 6 also describes techniques for verifying inventories using external data, i.e. data not used for inventory emission calculations.

In parallel with the implementation of the 2006 (or revised 1996) IPCC Guidelines, there is an ongoing process of ***refinement of the 2006 IPCC Guidelines***. The overall objective of this refinement is to provide an updated and sound scientific basis to support the preparation and continuous improvement of national GHG inventories, including also future international climate action under the Paris Agreement. This process should result in a Methodology Report to be used in conjunction with the 2006 IPCC Guidelines. The IPCC approved the outline for the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The ongoing process of refinement of the IPCC Guidelines is another entry point for NSOs to contribute directly with their expertise in data processes, including data collection and QA/QC. NSOs can contribute to the IPCC expert and/or government reviews for the sectors and cross-cutting elements of the IPCC refinement where NSOs have expertise. This is an excellent entry point to more involvement by NSOs in GHG inventories, as the 2019 refinement should eventually be used by Parties as the key methodological guidance for reporting GHG inventories in the future. The IPCC Methodology Report will be finalized in May 2019.

As mentioned earlier, and noting there are still ways within existing reporting and review processes for NSOs to be more involved in GHG inventories, the Paris agreement opens new possibilities for more involvement of NSOs in GHG inventories. An enhanced and global transparency framework and new data-related requirements, some of them beyond inventories, should open up much larger opportunities to contribute to these processes within the various institutional roles and responsibilities agreed at national level.

5. Definitions of quality in GHG inventories and in official statistics

For the purpose of Annex I GHG inventories, quality has been clearly defined in the UNFCCC Reporting Guidelines as comprising transparency, accuracy, consistency, comparability and completeness (TACCC).

Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information;

Consistency means that an inventory should be internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Good Practice Guidance for Land Use, Land-Use Change and Forestry;

Comparability means that estimates of emissions and removals reported by Annex I Parties in inventories should be comparable among Annex I Parties. For this purpose, Annex I Parties should use the methodologies and formats agreed by the COP for estimating and reporting inventories. The allocation of different source/sink categories should follow the split of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, at the level of its summary and sectoral tables;

Completeness means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC Guidelines as well as other existing relevant source/sink categories which are specific to individual Annex I Parties and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks of an Annex I Party;

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies should be used, in accordance with the IPCC good practice guidance, to promote accuracy in inventories.

In addition to the definition of consistency of the UNFCCC Reporting Guidelines, there is another type of consistency relevant to data production, which is the ***coherence between different reporting obligations.*** There are important consistency links between the reporting of GHG inventories under the UNFCCC and of air pollution inventories under the Convention on Long-range Transboundary Air Pollution (LRTAP). Although both Conventions follow different reporting requirements, the quality criteria to be applied to the reported data follow similar guidelines. Also, as with GHG inventories, air emission accounts draw from and complement air pollution inventories to allocate emissions following the national accounts' residence principle.

There are similarities between the UNFCCC *quality-criteria principles* (TACCC) applicable to GHG inventories as well as some of the approaches for data collection, QA/QC and cross-cutting elements of the IPCC Guidelines and the 15 principles of the European Statistics Code of Practice for the production and dissemination of European official statistics. One of these principles is the 'commitment to quality'; i.e. 'Statistical authorities are committed to quality. They systematically and regularly identify strengths and weaknesses to continuously improve process and product quality'. For NSOs, quality usually refers to adherence to quality standards in the framework of the UN Fundamental Principles of Official Statistics and the European Statistical System Code of Practice[8]. However, quality and quality improvements are embedded in GHG inventories and thus NSOs and GHG inventory compilers should strive to having close/r collaboration to improve emission estimates in GHG inventories, while fulfilling

[8] As already described in section 4.6 'quality assurance and guidelines' of the CES Recommendations on Climate Change-related Statistics' the most important difference in the quality frameworks of official statistics and GHG inventories are the institutional frameworks for data production. For official statistics, the European Statistical System Code of Practice and the UN Fundamental Principles of Official Statistics include standards for professional independence, mandate for data collection, adequacy of resources, quality commitment, statistical confidentiality, impartiality and objectivity. Of these, the UNFCCC reporting guidelines only refer to confidentiality. However, there are also many similarities between both frameworks. The European Statistical System Code of Practice requires relevance, accuracy, reliability, timeliness, coherence, comparability, accessibility and clarity. The UNFCCC reporting guidelines suggest similar criteria for the annual GHG inventories including transparency, consistency, comparability, completeness and accuracy. A comparison of the quality criteria for official statistics and GHG inventories are provided in Annex 5 of the CES recommendations.

each-others objectives in parallel. These synergies support the argument that more active involvement from NSOs can add value to GHG inventories.

6. Data needs in GHG inventories, data quality and estimation methods

Quality and quality improvements - This is arguably the core of NSOs input to GHG inventories. The quality of GHG estimates is as good as the underpinning activity data. Some of this activity data is collected by NSOs and provided to GHG inventory compilers. Previous UNECE work concluded that NSOs have expertise with different classification systems and statistical frameworks. This indeed can play a role in the first stages of GHG inventory compilation when key categories and methods for data collection are identified. In addition, NSOs are already significant data providers, including data on energy production and consumption, agriculture, forestry, mining, waste generation, manufacturing, transportation and land cover, and other areas of relevance to GHG inventories. Finally, NSOs have expertise in developing new data and ensuring the high quality of all statistics they produce. When producing new data for the purpose of GHG inventories, NSOs can ensure that these new data and associated methodologies become part of the national statistical process, thus ensuring business continuity.

There are more synergies that one may think between GHG inventory compilers and NSOs, but both communities need to speak the same language. The common denominator is quality and quality improvements. There are many similarities between, for example, the 15 principles of the European Statistics code of practice and the UNFCCC TACCC quality principles, as explained earlier. The main issue is not so much the format of the data (e.g. CRF vs NACE) but rather that that the relevant statistical data is available and shared with national GHG inventory compilers, and that there is a system in place to ensure the quality of the data and the improvements over time. The quality of emission estimates reflects to a large extent the quality of the national system or institutional arrangements for inventory preparation, where NSOs should play a bigger role.

'Approaches to data collection' of the 2006 IPCC Guidelines - Data collection is a fundamental part of inventory preparation. This IPCC chapter provides guidance on initiating and maintaining a data collection program, covering also the evaluation of existing sources of data as well as planning new emission measurements and surveys. Formalised data collection activities should be established, adapted to countries' national circumstances, and reviewed periodically. In most cases generating new source data will be limited by the resources available and prioritisation will be needed, taking account the results of *key category* analysis set out in the chapter referring to 'methodological choice and identification of key categories'. According to the Guidelines, the methodological principles of data collection that underpin '*good practice'* are:

1. Focus on the collection of data needed to improve estimates of *key categories* which are the largest, have the greatest potential to change, or have the greatest uncertainty.
2. Choose data collection procedures that iteratively improve the quality of the inventory in line with the data quality objectives (e.g. transparency, consistency, comparability, completeness and accuracy).

3. Put in place data collection activities (resource prioritisation, planning, implementation, documentation etc.) that lead to continuous improvement of the data sets used in the inventory.
4. Collect data/information at a level of detail appropriate to the method used, and relevant for the emission factors to be used/reported.
5. Review data collection activities and methodological needs on a regular basis, to guide progressive, and efficient, inventory improvement.
6. Introduce agreements with data suppliers to support consistent and continuing information flows.

A wide range of statistics are needed for inventory production. Examples of statistics that can be used:

Emission source category	Examples of statistics relevant for emission calculations
Energy	Energy statistics and energy balances
	EU/national ETS data or other plant-specific data
	Surveys on energy use in households or specific industries
	Transport statistics
Industry	Production statistics
	External trade statistics
	National accounts
Agriculture	Agricultural statistics (e.g. number of animals of different husbandry types)
	Spatial/land use statistics
	Censuses of agriculture (e.g. on manure management systems)
Land use, land use change and forestry (LULUCF)	Spatial/land use statistics
Waste	Waste statistics/waste accounts
	Statistics on wastewater treatment

Note: The introductory sectoral chapters of the 2006 IPCC Guidelines include general information on the use of activity data in the estimation of GHG emissions. More detailed information can be found in the relevant sectoral sub-chapters.

Regarding estimation methods, the simplest methodological approach is to combine information on the extent to which a human activity takes place (called activity data or AD) with coefficients which quantify the emissions or removals per unit activity (called emission factors or EF). The basic equation is:

Emissions = AD • EF

The above method is an example of a Tier 1. In the Guidelines, a tier is linked to the level of methodological complexity. There are three tiers: Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements. In general, tier 1 methods are designed to use readily available national or international statistics in combination with the IPCC default emission factors and should be feasible for all countries. Tiers 2 and 3 are referred to as higher tier methods and are generally considered more accurate. In general, it is good practice to use higher tier methods for key categories, unless the resource requirements to do so are prohibitive.

The following descriptions apply to the tiers in the energy sector:

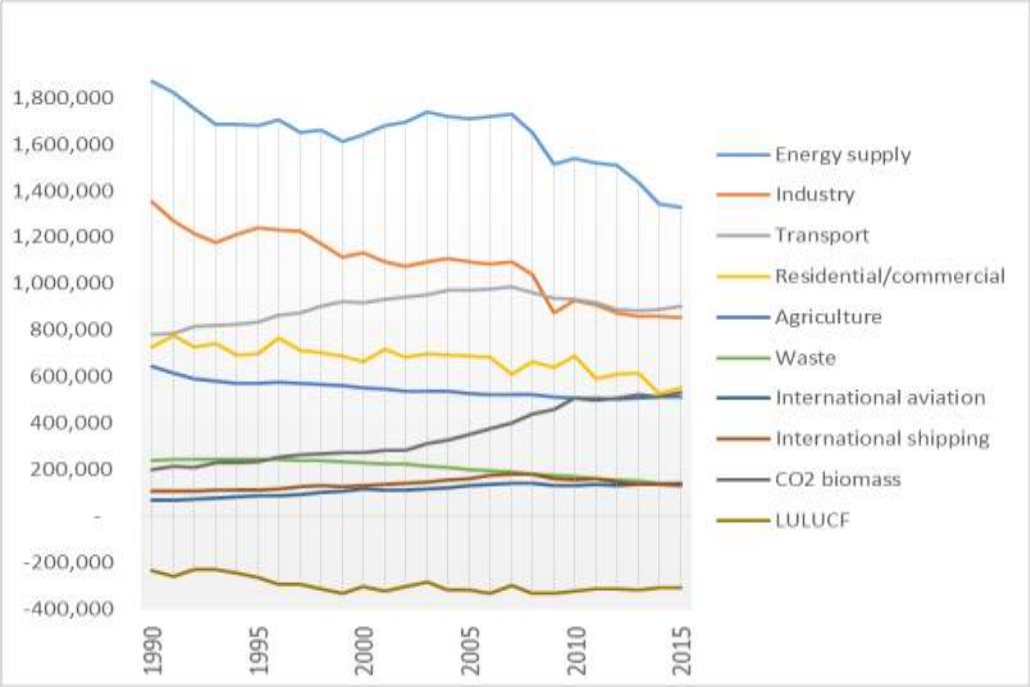
a) Tier 1: fuel combustion from national energy statistics and default emission factors from the IPCC Guidelines.
b) Tier 2: fuel combustion from national energy statistics, together with country-specific emission factors, where possible, derived from national fuel characteristics;
c) Tier 3: fuel statistics and data on combustion technologies applied together with technology-specific emission factors; this includes the use of models and facility level emission data where available.

Examples of data needs and data uses in the EU GHG inventory - To give an example, the EU GHG Inventory is based on Member States' (MS) GHG inventories. Thus, national data sources underpinning MS emissions are also the data sources underpinning EU emissions. What all MS have in common is the use of EU ETS data as well as of energy statistics and transport statistics[9]. While the primary data sources for the EU inventory are MS inventories, the EU uses international verification sources for the QA/QC of the activity data submitted by its MS for the preparation of the EU GHG inventory. These sources include, inter alia, Eurostat for the IPCC Reference Approach of CO_2 emissions from fossil fuel combustion as well as Eurocontrol for domestic and international fuel consumption and emissions. Data quality is essential for good quality GHG inventories and verification using international data sources help or can help improve the confidence in the reported GHG emissions estimates.

For a snapshot of the aggregated sectoral breakdowns used in GHG inventories, figure 1 shows GHG emissions by (CRF) sector over the 25-year period for the EU-28. The exact level of detail expected from Annex I Parties can be seen in the CRF tables reported to UNFCCC. See for example the latest GHG inventory submissions (column CRF) on the UNFCCC website.

[9] In general terms, all EU Member states use EU ETS data in the estimation of GHG emissions, mainly from energy transformation industries and industrial processes. Energy statistics capture by and large the underpinning activity data from the EU ETS. ETS covers above 40% of total GHG emissions. The sectors not included under the ETS, such as transport, waste and agriculture, as well as a part of industrial processes, are responsible for the remainder. Statistics here come from a vast array of different sources depending on MS.

Figure 1 GHG emissions by sources and sinks in EU-28, 1990-2015 (kt CO2 eq.)



Source: EEA report: Analysis of key trends and drivers in greenhouse gas emissions in the EU between 1990 and 2015 https://www.eea.europa.eu/publications/analysis-of-key-trends-and , EEA.

What is particularly interesting about data usually collected by NSOs is that they also complement the analysis of GHG emission trends in GHG inventories. These are per se relevant for emissions of GHGs but inventories may not provide all the information needed to understand why emissions increase or decrease. The analysis of emission drivers needs additional data. One example, from the same EEA report as above, is the following decomposition analysis based on the Kaya identity (figure 2).

Figure 2 breaks down the 25-year 24% overall reduction in GHG emissions in the EU, for the 3 different periods, into several factors using the Kaya decomposition identity[10].

Overall, the four main findings from the decomposition analysis of figure 6 are[11]:

i. Emissions decreased with increasing GDP (per capita) during all periods considered (1990-2000, 2000-2008, and 2008-2015). This shows that emissions can decrease with a growing economy. But it

10 The chosen factors are an extension of the Kaya identity. The annual decomposition analysis shown in this paper is based on the Logarithmic Mean Divisia Index (LMDI) method. The equation for the aggregated decomposition analysis is:

(y) [ln]GHG = (x_1) [ln]POP + (x_2) [ln]GDP/POP + (x_3) [ln]PEC/GDP + (x_4) [ln]GHG_en/PEC + (x_5) [ln]GHG/GHG_en, where:

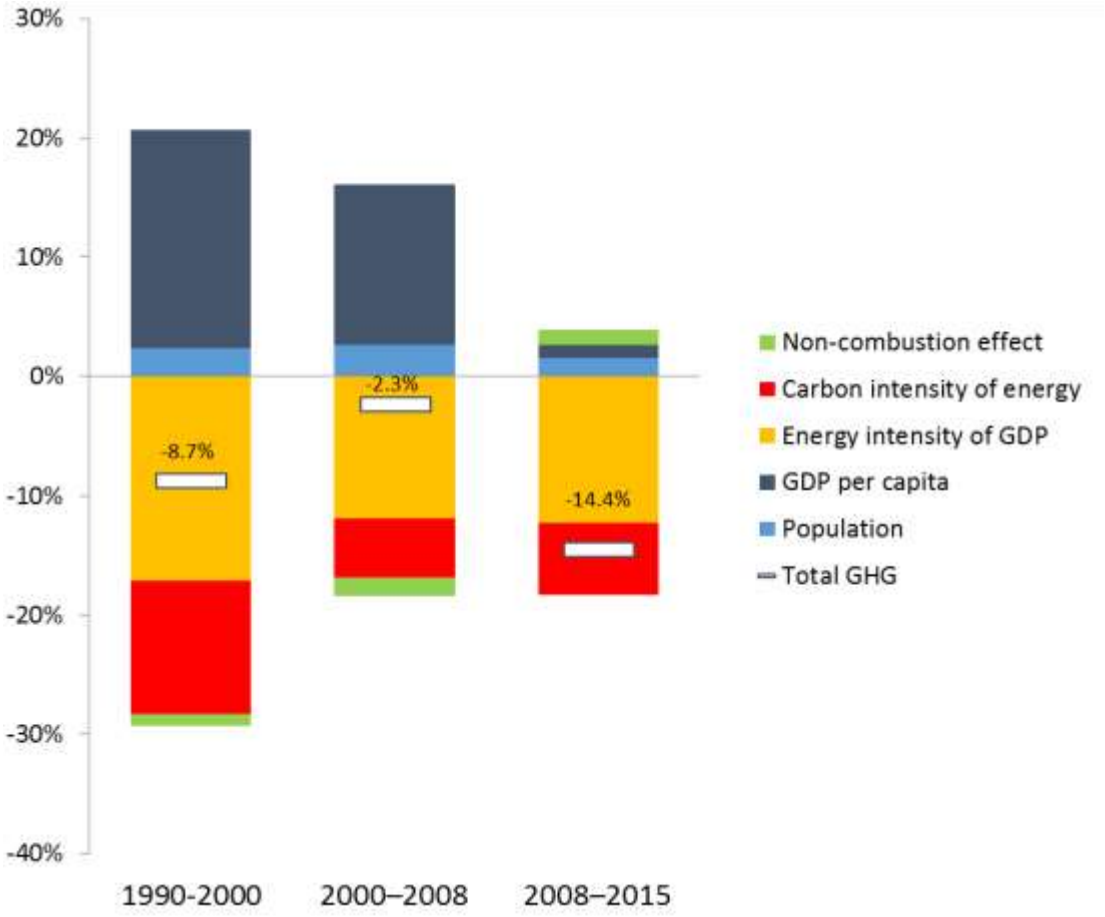
(y) GHG: total GHG emissions; (x_1) POP: population (population effect); (x_2) GDP/POP: GDP per capita (affluence effect); (x_3) PEC/GDP: primary energy intensity of the economy (primary energy intensity effect); (x_4) GHG_en/PEC: energy-related GHG emissions in primary energy consumption (carbon intensity effect); (x_5) GHG/GHG_en: total GHG emissions in energy-related GHG emissions (non-combustion effect).

11 When interpreting the results from this decomposition analysis, one should be careful not to extrapolate everything that is not GDP to policies or other factors which are assumed to be independent from the economy. Recession is broader than GDP, and there is a recession effect in 'energy intensity' (e.g. lower fuel use by industry), or in 'carbon intensity' (e.g. if recession affected relative fuel prices).

also suggests that emissions may decrease faster with a stagnating economy, and/or a declining economy as concluded by previous EEA work[12] . The economic recession has resulted in substantial emission reductions in the last period, particularly until 2013.

ii. The lower carbon intensity of energy was a key factor underpinning lower emissions in all three periods. This factor has been stronger in the period of 2008-15 than in the period 2000-08, despite a decline in nuclear electricity production. The lower carbon intensity during both 2005-08 and 2008-15 is by and large accounted for by a higher contribution from renewable energy sources in the fuel mix. In the 1990s, renewables, although still positive, contributed less to emissions reductions compared to nuclear; however, the largest factor of emission reductions was the switch between more carbon-intensive coal to less carbon intensive gas.

Figure 2 Decomposition of the cumulative changes in total GHG emissions in the EU-28 in three different periods: the 1990s, the 2000s before the recession, and post-2008



Note: The explanatory factors should not be seen as independent of each other. The bar segments show the changes associated with each factor alone, holding the respective other factors constant.

Source: EEA.

12 See section 7 'The role of economic growth and recession in GHG emission reductions in the EU 'of 'Why did GHG emissions decrease in the EU between 1990 and 2012', published in 2014 http://www.eea.europa.eu/publications/why-are-greenhouse-gases-decreasing

i. The decrease in primary energy intensity was the largest contributing factor to lower CO_2 emissions from fossil fuel combustion in all three periods. In the last period 2008-15, total energy consumption decreased while GDP increased, leading to an improvement in the emissions intensity of energy production and use. The economic recession partly explains lower energy demand from industry and road transportation since 2008. However, energy intensity also decreased in the periods 1990-2000 and 2000-2008 where energy demand was high. Lower energy intensity of GDP can be explained by improvements in energy efficiency (transformation and end-use) and the strong uptake of renewables, as well as by changes in the structure of the economy and a higher share of the services sector compared to the more energy intensive industrial sector.

ii. The largest emission reductions occurred in the energy-combustion sector. Contributions from other sectors, particularly industrial processes, waste and agriculture have also been important. In the last period, non-energy emissions decreased, though at a lower rate than energy-related'.

Clearly, this analysis would not be possible without the additional data reported to and publish by NSOs, in this case Eurostat (i.e. energy statistics, population statistics and economic national accounts).

7. Institutional arrangements for GHG inventories

A good national system for GHG inventories - is essential for delivering good quality emission estimates. Quality improvements are intrinsic to the annual reporting of GHG inventories. Under the Kyoto Protocol each Party is required to set up a 'national system' for the estimation of emissions by sources and removals by sinks aimed at ensuring and improving the quality of GHG inventories through planning, preparation and management of inventory activities. These activities include collecting activity data, selecting the appropriate methods and emission factors, estimating GHG emissions/sinks, implementing QA/QC procedures and verification of national data.

The *Guidelines for national systems* used by Annex I Parties that have ratified the Kyoto Protocol define the general and specific functions of a good national system. In many countries GHG inventory compilation is coordinated by Environment Ministries or other organizations, which serve as the UNFCCC Focal Point. The national inventory systems comprise all the institutional arrangements, usually enforced by legislation, within a country to prepare and submit GHG inventories.

Among the *general* functions it is worth highlighting two of the requirements related to the implementation of the national system. Each Party included in Annex I shall:

1. Establish and maintain the institutional, legal and procedural arrangements necessary to perform the functions defined in these guidelines for national systems, as appropriate, between the government agencies and other entities responsible for the performance of all functions defined in these guidelines;
2. Ensure sufficient capacity for timely performance of the functions defined in these guidelines for national systems, including data collection for estimating anthropogenic GHG emissions by sources and removals by sinks and arrangements for technical competence of the staff involved in the inventory development process;

To perform the general functions, each Party included in Annex I shall undertake *specific* functions relating to inventory planning, preparation and management.

1. ‘Planning’: Define and allocate specific responsibilities in the inventory development process, including those relating to choice of methods, data collection, particularly activity data and emission factors from statistical services and other entities, processing and archiving, and QC and QA. This definition shall specify the roles of, and cooperation between, government agencies and other entities involved in the preparation of the inventory, as well as the institutional, legal and procedural arrangements made to prepare the inventory;
2. ‘Preparation’: Identify key source categories following the methods described in the IPCC good practice guidance (chapter 7, section 7.2); (b) Prepare estimates in accordance with the methods described in the IPCC Guidelines, and ensure that appropriate methods are used to estimate emissions from key source categories; Collect sufficient activity data, process information and emission factors as are necessary to support the methods selected for estimating anthropogenic GHG emissions by sources and removals by sinks;
3. ‘Management’ Archive inventory information for each year in accordance with relevant decisions of the COP and/or COP/MOP. This information shall include all disaggregated emission factors, activity data, and documentation about how these factors and data have been generated and aggregated for the preparation of the inventory. This information shall also include internal documentation on QA/QC procedures, external and internal reviews, documentation on annual key sources and key source identification and planned inventory improvements;

It is important to stress that the internal set-up (i.e. national system) to deliver high quality emission inventories varies across countries. As mentioned in the introduction, the decision of how to organise the national inventory system should be discussed in the national context and coordinated through the national focal points to UNFCCC. Some NSOs are already part of the national inventory system, or, if not yet part of it, could be part of the national inventory system given the expertise and data they can provide to improve the quality of GHG inventories. This may become more relevant with the implementation of the Paris agreement and the requirements to submit GHG inventories, using common guidelines, by all Parties. The actual role of NSOs in the national system and/or their involvement in the compilation process also varies from country to country. The key issue is however to ensure that the relevant statistical data is available and shared with national GHG inventory compilers. The quality of emission estimates reflects the quality of the national system, where NSOs play or should play an important role.

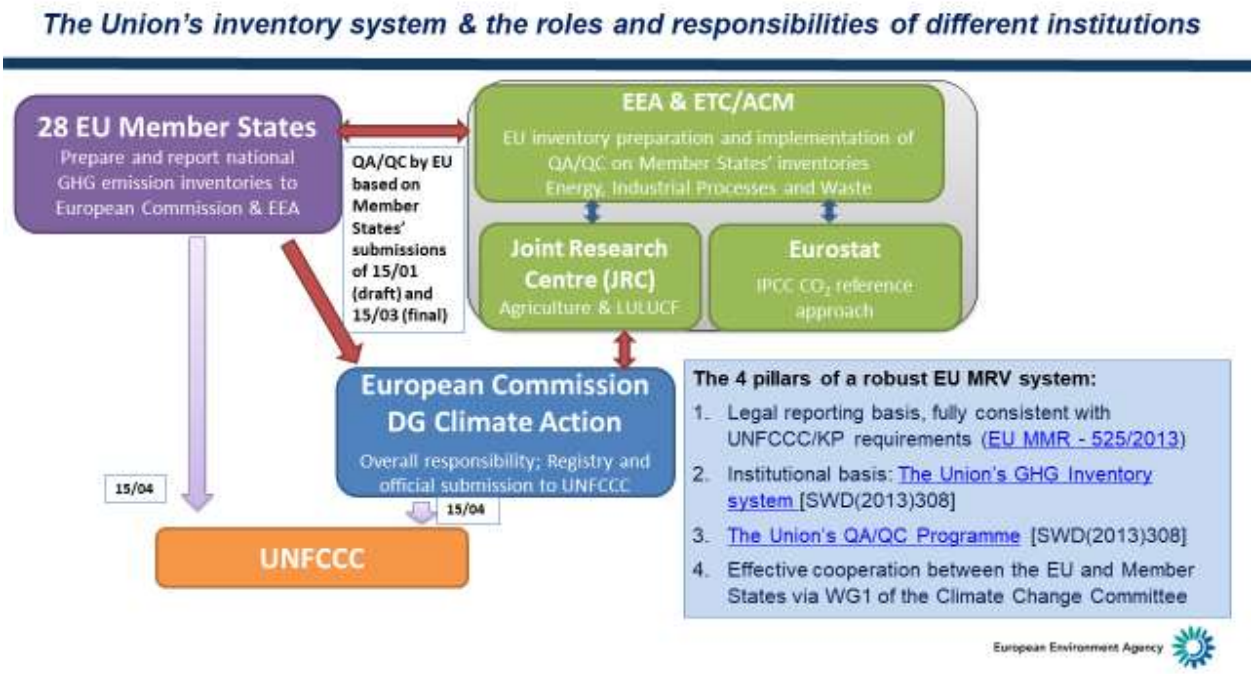
Whereas changes to the national system are always possible, changing the institutional set-up and/or the roles of each institution during the current Kyoto Protocol commitment period may not be efficient or needed, especially if the current set-up works efficiently by delivering good quality GHG inventories. In other instances, the current set-up could be improved in various ways, while ensuring business continuity. One such possibility could be expanding the role of NSOs or including NSOs in the relevant national GHG inventory system. Formalising institutional relations provides certainty about the roles and responsibilities of each institution. Although this is a decision for the competent authority in the country, there are benefits of having NSOs being part of the formal inventory process, as they can help ensure and improve the quality in GHG inventories on a sustainable basis. Opportunities open up greatly with the future implementation of the Paris agreement and the requirement to submit GHG inventories by all Parties.

Example of how the national system is organized in the EU

At EU level we have 4 pillars to ensure that the EU GHG inventory complies with UNFCCC/IPCC guidelines, which is the basis for a solid and reliable MRV system: These pillars are

1. Legal reporting basis, which are fully consistent with UNFCCC/KP requirements
   a) Regulation of the European Parliament and of the Council (EU) 525/2013
   b) Commission Implementing Regulation (EU) No 749/2014 on structure, format, submission processes and review
   c) Commission Delegated Regulation (EU) No 666/2014 establishing substantive requirements for a Union inventory system
2. Institutional basis: The Union's GHG Inventory system (see chart below)
3. The Union's QA/QC Programme
4. Effective cooperation and coordination between the EU and its Member States via the Climate Change Committee (WG1 on GHG inventories): Essential part of the EU's inventory work.

Figure 3 The EU's GHG national system



GHG inventory compilers and reviewers would generally agree that the most important element for a good and sustainable GHG inventory are the institutional arrangements or national system defining the roles and responsibilities of the different institutions involved in the inventory preparation, reporting and review. Figure 3 is an example of how the EU national system is organised, starting with the 28 EU MS reporting their GHG inventories to the European Commission and the EEA, as the EU GHG Inventory Agency.

Because of the Joint Fulfilment agreement under the Kyoto Protocol and the internal target-setting to deliver the GHG emission reductions agreed internationally by the EU and its MS jointly, the EU GHG inventory is based on data reported by its Member States. The EU does not produce its own emission estimates. The Member States are responsible for the quality of activity data, emission factors and other parameters used for their inventories.

The role of Eurostat, as EU's NSO & integral part of the EU's National System - Eurostat collects national energy statistics reported under the EU Energy Statistics Regulation on an annual basis. These data are used for the estimation of the IPCC Reference Approach and the Sectoral Approach. The EEA compares the results of the two approaches with MS CRF submissions. These comparisons are sent to MS during the consultation on the Draft EU GHG inventory by 28/02. The Energy Statistics Regulation (Regulation EC/1099/2008) as amended by Commission Regulation (EU) No 147/2013 of 13 February 2013 is the basis for MS reporting of energy data to Eurostat. Article 6(2) of the Energy statistics regulation stipulates: 'Every reasonable effort shall be undertaken to ensure coherence between energy data declared in the energy statistics regulation, and data declared in accordance with Commission Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol'. The consistency of energy balances and CRF activity data is essential for good quality GHG estimates in the energy sector, and therefore it is at the core of the QA/QC activities at EU level.

Other examples of national GHG inventory systems are shown in figures 4 and 5 below for Norway and Finland, respectively.

Figure 4 The GHG national system in Norway

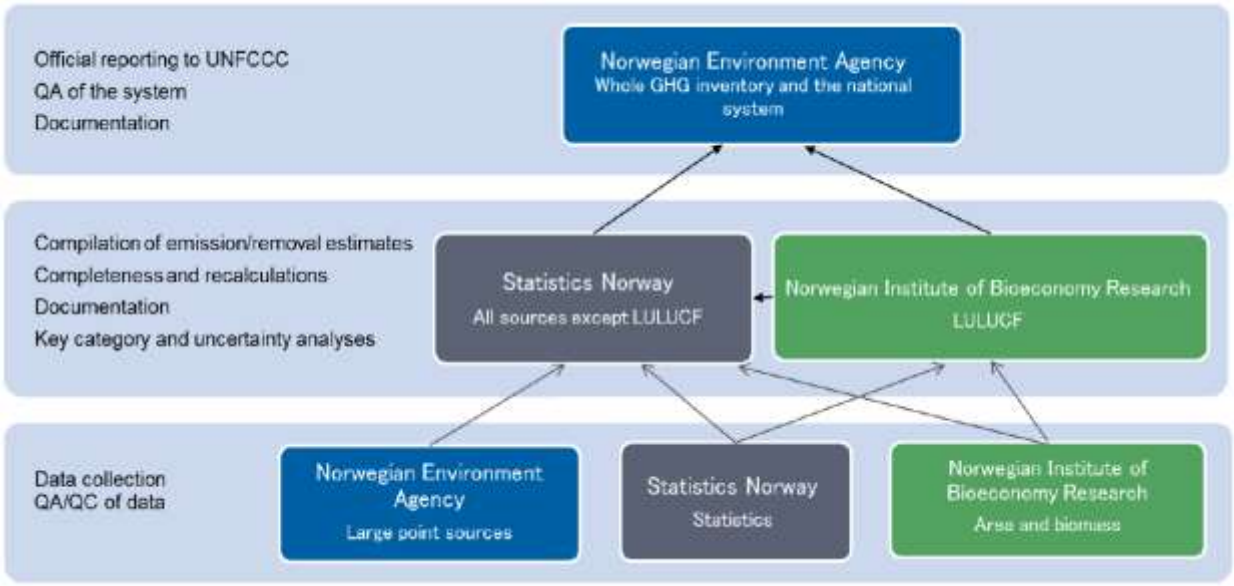
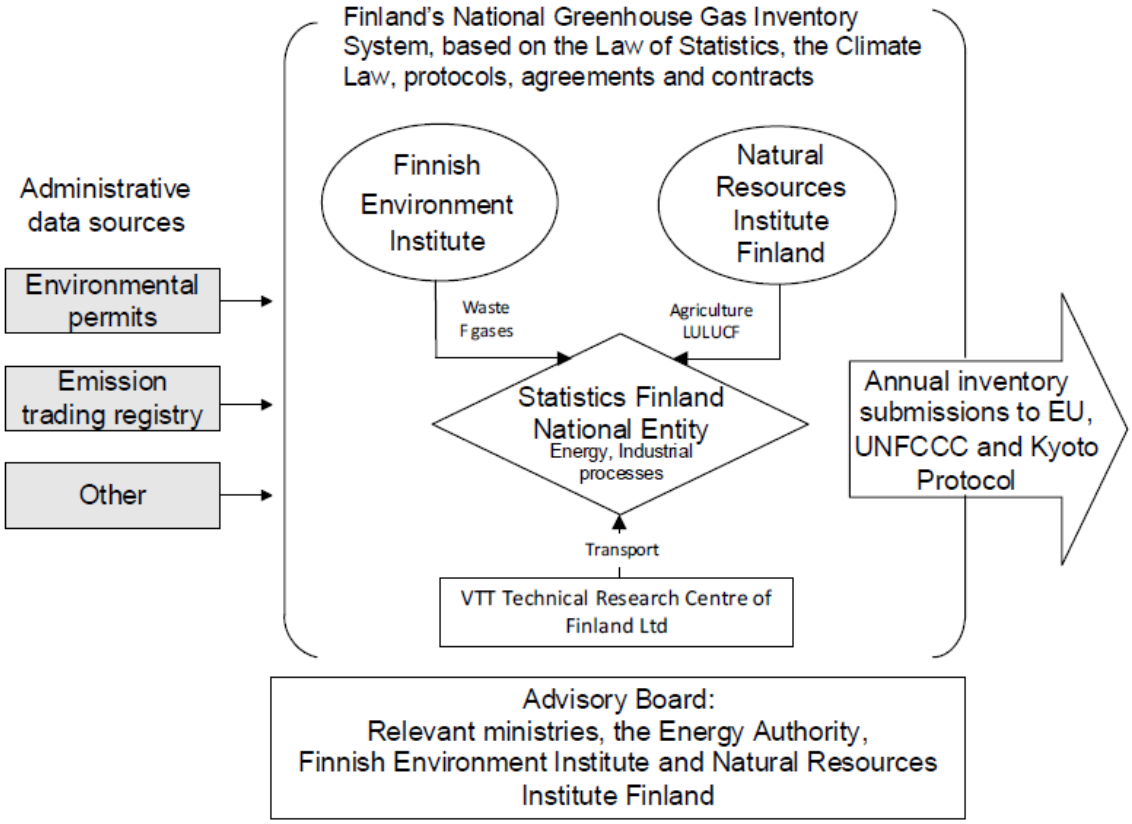


Figure 5 The GHG national system in Finland



There is no prescriptive way for organising one's National Inventory System. What works in one country may not work as well in another country. It is a national decision. However, it would always work better to formalise agreements legally, if possible, to ensure that everyone delivers what they have to deliver and when they have to deliver. Gentlemen's agreements can work when there is no conflict with other legally binding agreement in terms of human and/or financial resources.

8. Steps in a typical GHG inventory cycle

The introductory chapter of the 2006 IPCC Guidelines also provides an example of the *steps needed in a typical inventory cycle*, with quality control measures implemented and documented for every step.

1. The first step for a revised or new greenhouse gas inventory is to identify the key categories for the inventory so that resources can be prioritized. Where an inventory already exists, the key categories can be identified quantitatively from the previous estimates. For a new inventory the compiler will have to make a preliminary assessment based on local knowledge and expertise about large emission sources and inventories in countries with similar national circumstances or, if possible, make preliminary Tier 1 estimates to assist in identifying key categories. Assessing the key categories helps the inventory compiler to focus effort and resources on the sectors that contribute most to the overall inventory or

inventory uncertainty and so helps to ensure that the best possible inventory is compiled for the available resources.

2. Once the key categories have been identified, the inventory compiler should identify the appropriate method for estimation for each category in the particular country circumstances. The sector-specific decision trees in Volumes 2-5 and the generalised decision tree in Chapter 4 of Volume 1 provide guidance on selecting appropriate methods. The selection of methods will be determined by the classification of a category as key or not key, and by both the data and the resources available. Guidance on data collection is provided in Chapter 2 of Volume 1.

3. Data collection should follow the selection of the appropriate methods. (See Chapter 2, 5 and 7 in Volume 1). Data collection activities should consider time series consistency and establish and maintain good verification, documentation and checking procedures (QA/QC) to minimise errors and inconsistencies in the inventory estimates. Data on uncertainties should if possible be collected at the same time. Guidance on the collection of new data in a cost effective way and on uncertainties is provided in Chapter 2 and Chapter 3 of Volume 1 respectively. QA/QC activities should continue throughout this process to minimise errors and document data sources, methods and assumptions. The results of the data collection may lead to refinement of the methods chosen.

4. Emissions and removals are estimated following the methodological choice and data collection. Care should be taken to follow the general guidance in Chapter 5, Time Series Consistency in Volume 1 especially if the data are incomplete for some years. Once the inventory estimates are complete, the next step is to perform an uncertainty analysis and key category analysis (see Chapters 3 and 4 in Volume 1). These analyses may identify categories for which a higher tier should be used and additional data collected.

6. Following the completion of the final quality assurance (QA) checks, the final step in the inventory process is to report the inventory (See Chapter 8 in Volume 1). The aim here is to present the inventory in an as concise and clear way as possible to enable users to understand the data, methods and assumptions used in the inventory. Provision of concise relevant background information and explanations in the reports helps to ensure the inventory (including the report) is transparent.

The inventory compiler should base future inventory revisions on previous inventories. Thus an iterative process builds on and improves the inventory each time a new inventory is compiled. When a revised inventory is compiled, all years' estimates should be reviewed for consistency and updated integrating any feasible improvements where necessary. Chapter 5 in Volume 1 gives advice on compiling consistent time series and provides good practice approaches for achieving time series consistency.

The involvement of NSOs in this process will vary from country to country and will also depend on whether an inventory already exists and whether NSOs are either in the inventory system formally or rather contribute to the inventory on the margins of the formal institutional set-up. At first sight steps 1 to 3 could be of most relevance to NSOs, thus just not data collection activities or QA/QC per se but also the identification of key sources of emissions (relevant for resource prioratization) for which detailed activity data would be necessary for estimating emissions using higher tier methods.

9. Quality review in GHG inventories

UNFCCC review process – One of the key objectives of the UNFCCC Annex I inventory review guidelines is that the COP is provided with an objective, consistent, transparent, thorough and comprehensive technical assessment of the quantitative and qualitative inventory information submitted annually by Annex I Parties. The UNFCCC review process adds an extra layer to the QA/QC within the national inventory system to ensure data quality and that this quality is improved over time. The quality of the reported emissions is subject to international scrutiny by independent review experts from all over the world.

The review of greenhouse gas (GHG) inventories comprises two stages. Each stage complements the previous one. Review reports are prepared and published on the secretariat web site.

1. Initial assessment by the UNFCCC Secretariat: a standardized set of data comparisons mainly based on the CRF data, aiming to examine that each Annex I Party has submitted a consistent, complete and timely annual inventory in the correct format, and to identify issues for further consideration during the review of individual inventories. Assessment reports are available to Parties and expert review teams (ERTs);
2. Review of individual annual inventories by ERTs (either as desk reviews, centralized reviews or in-country reviews): ERTs examine the data, methodologies and procedures used in preparing the national inventory. ERTs are required to pay particular attention to key categories, areas of the inventory where issues have been identified and recommendations made in previous reviews, or stages of the review, progress in the implementation of the planned improvements, or where recalculations or other changes have been reported by the Annex I Party. Individual review reports are published for each Party.

The GHG inventory reviews under UNFCCC are also an excellent source of information to finding and/or increasing the 'NSO niche' in the GHG inventory process. Expert review teams (ERTs) more often than not recommend Parties to improve the background activity data underpinning GHG emission estimates in the annual review reports (ARRs). Recommendations can range from better coordination and collaboration between agencies involved in inventory preparation, to better and more transparent QA/QC of activity and emissions data, and better coherence/consistency in data reported to different organisations. People working for NSOs can also participate in GHG inventory reviews under UNFCCC and contribute more directly to quality improvements of other countries' GHG inventories.

The process of QA/QC starts before international review - The key objective should be to improve the quality and availability of data underpinning GHG emission estimates. Where NSOs are part of the national GHG inventory system, these improvements should be part of the Party's QA/QC Programme. Inventory compilers are often users of NSOs data which underpin GHG inventory estimates. NSOs can always initiate these quality improvements for the data falling within their mandate. NSOs can also refer to the 'key source analysis' reported in GHG inventories to determine the most pressing lack of activity data (and/or quality) affecting emissions.

Example of QA/QC at EU level

There are 4 broad types of QA/QC during the EU Inventory compilation:

1. The QA/QC carried out by each MS before submission to the EU (drafts by 15/01 & final inventories submitted to the EU by 15/03)
2. The QA/QC by the EU team ('initial checks') on MS Inventory submissions (between 15/01 and the EU and MS' submissions to UNFCCC 15/04). Resubmissions are possible by 27/05.
3. The technical review under the Effort Sharing Decision, or ESD Review, as follow up to the 'initial checks' (normally in April/May)
4. The technical Review under UNFCCC/KP (September/October)

GHG inventory improvements are, where feasible, implemented by the next GHG inventory submission in a continued process, while taking into account the urgency of the recommendation and resources available.

Collaboration between NSOs and GHG inventory The EU institutional arrangements have been stable since its conception as the different institutions in the national system are working efficiently and delivering good quality emission inventories year after year. In any event, we strive for improved collaboration between statistical offices and GHG inventory compilers. Collaboration with Eurostat continues to be excellent. Due to its privileged role as the EU's statistical office and access to officially-reported data by Member States, further involvement in other sectors, in addition to energy combustion, would improve verification activities across all sectors of the EU GHG inventory.

Some of the most successful meetings related to GHG inventories are the ***Joint workshops*** linking the statistical and the inventory communities across EU member states. These include, for example, past joint workshop/s between Eurostat's Working Group on Energy Statistics and the European Commission's WG1 on GHG inventories under the Climate Change Committee. At the end of 2017 there was another joint workshop between Eurostat's WG on agro-environmental statistics and WG1 on GHG inventories.

The main objectives of these joint workshops are:

a. to increase the quality of GHG emission estimates and/or estimates;
b. to increase the cooperation between inventory compilers and statisticians in national statistical institutes;
c. to potentially reduce the burden on producers of data and respondents to various data collections; and,
d. to increase coherence in various reports and to improve data sharing and quality.

In many countries collaboration between institutions, and within institutions, works efficiently, while in other countries collaboration can improve, sometimes significantly.

10. Information on relevant training possibilities

Inventory-related training possibilities are available to get acquainted with UNFCCC/IPCC Guidelines for reporting and review, so that both communities (GHG inventory compilers and NSOs) speak the same language. There are a few entry points, including:

Training Programs for the Review of Information submitted by Annex I Parties to the UNFCCC – The training courses are available to experts nominated to the roster of experts by their national focal points to UNFCCC. The programs include training for: a) review experts for the technical review of greenhouse gas inventories of Parties included in Annex I to the Convention; b) members of expert review teams participating in annual reviews under Article 8 of the Kyoto Protocol; and c) review experts for the technical review of biennial reports and national communications of Parties included in Annex I to the Convention.

UNFCCC capacity building portal – developed in 2012 taking into consideration the need for an overview of activities and the intention to gather information on capacity-building support provided to developing countries. The information is submitted in accordance with the 15 priority areas for capacity-building identified in the annex to decision 2/CP.7.

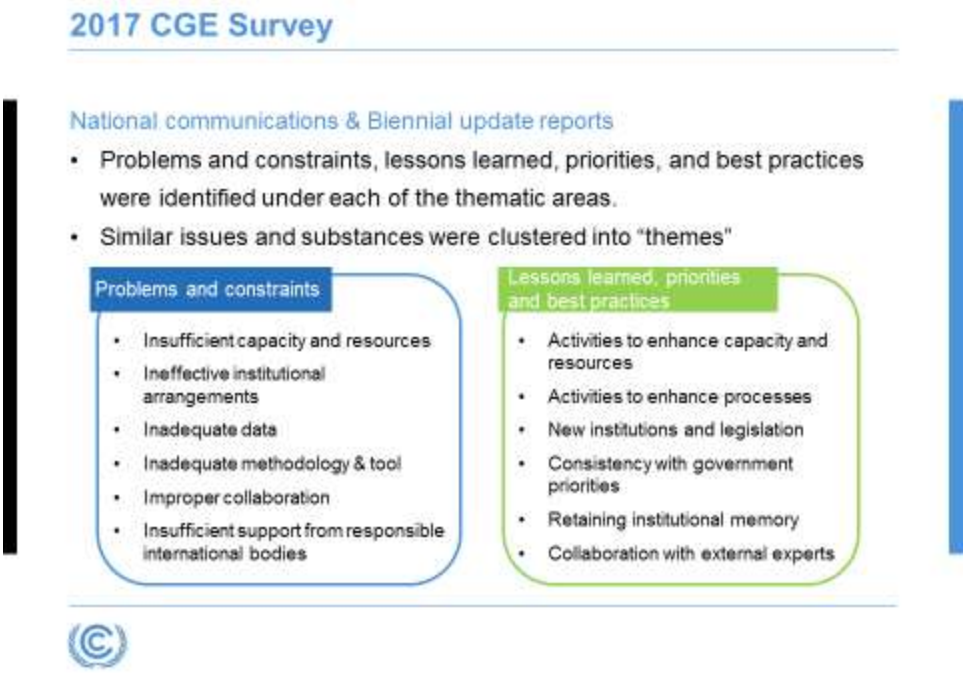
Consultative Group of Experts – The COP established the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE) with the objective of improving the process of preparation of national communications from non-Annex I Parties. To facilitate its work, the CGE set up the following four thematic groups: national GHG inventories, vulnerability and adaptation assessments, mitigation and cross-cutting issues which includes research and systematic observation, technology transfer, capacity-building, education, training and public awareness, information and networking and financial and technical support. The CGE training materials are available from the UNFCCC website.

IPCC task force on GHG inventories - The IPCC has set up the Task Force on Inventories (TFI) to run the National Greenhouse Gas Inventory Programme (NGGIP) to produce methodological advice, including the IPCC emission factor database and a number of relevant presentations to support inventory compilation.

11. Constraints, lessons learnt and best practices in GHG inventories, from the optic of developing countries

A technical report (FCCC/SBI/2017/16) by the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention provides a compilation and synthesis of problems, constraints, lessons learned and best practices in the process and preparation of NCs and BURs, including GHG inventory information.

Although the slide below is not restricted to GHG information, it gives a good overview of the key issues as well as best practices that many non-Annex I Parties still face in reporting to UNFCCC. It also highlights the importance of a strong institutional arrangements for inventory preparation.



The following sections present the problems and constraints, lessons learned and best practices relating to national GHG inventories in the process of and the preparation of NCs and BURs.

1. Problems and constraints in national GHG inventories

In most cases, custodians of relevant data do not engage in data collection with the preparation of national GHG inventories as the primary objective. Consequently, the format of the data might not be suitable for the purpose of the national GHG inventory or the data might be incomplete. Some of the specific data collection problems identified by non-Annex I Parties include that:

(a) Data are highly aggregated and therefore unsuitable for the preparation of a national GHG inventory that is consistent with the IPCC guidelines;

(b) Data management systems for national GHG inventories are inadequate, rendering data archiving and use challenging. In most cases, custodians of data do not have the capacity to archive them for several years and tend to lose track of data archived over a period of years. Also, data are archived in different formats and in multiple locations across different agencies, and, as such, obtaining and using them is challenging. This challenge often leads to a failure to retain institutional memory;

(c) Data collection lacks formal arrangements and the data are often assembled from various sources, thus uncertainty increases. In addition, the data are often without sufficient metadata. This renders the data unverifiable and inconsistent.

Some non-Annex I Parties have found the default emission factors and/or other emission factors contained in the IPCC emission factor database not to be applicable to their national circumstances. While the use of country-specific emission factors would reduce uncertainty and increase the accuracy

of national GHG inventories, most non-Annex I Parties lack the expertise and resources to facilitate their development.

Parties with ineffective institutional arrangements tend to collect activity data on an on-demand basis, with no obligation on the part of data generators to periodically collect and submit complete data to the NC/BUR team or a designated national GHG emission data coordination centre. Some companies are prepared to use litigation to avoid sharing data for the preparation of national reports.

2. Lessons learned in national GHG inventories

Some non-Annex I Parties are taking advantage of work done in other projects related to the UNFCCC process. For example, country-specific emission factors and methodologies developed in sustainable transport, energy efficiency and biomass projects, mostly funded by the Global Environment Facility (GEF), are being used in preparing national GHG inventories.

Better statistical sampling and standardized measurements are perceived by non-Annex I Parties to be means of improving the quality of country-specific emission factors. Industry associations are being engaged in developing country-specific emission factors in some non-Annex I Parties. Further, work to develop methods for collecting primary data rather than relying on secondary data has been carried out in some non-Annex I Parties.

Updating and revising details and assumptions included in previous NCs has improved the quality of data available to some non-Annex I Parties for the preparation of their national GHG inventories. The updates and revisions are being done by consulting recently published national economic development and demographic parameters in order to develop more accurate estimates.

Non-Annex I Parties are developing various ways of dealing with data-related issues, including:

(a) Raising the awareness of data custodians and key stakeholders of data gaps and methods for data collection, as well as dedicating resources to exploring approaches to dealing with data gaps. For addressing smaller data gaps, and when attempting to make highly aggregated data useful, some non-Annex I Parties have used extrapolation, averages, downscaling and expert judgment. MOUs with relevant institutions to facilitate data sharing are being established in cases of data scarcity, while other non-Annex I Parties have created and shared simple data collection spreadsheets with relevant departments. The latter approach has been accompanied by training courses for professionals working in relevant sectors, with a view to harmonizing understanding and ensuring consistency;

(b) Ensuring the continuous flow of data from national institutions to the designated entity for the preparation of NCs and BURs by establishing a national GHG inventory system to collect and organize data according to the IPCC national GHG inventory sectors and to disseminate GHG emission data. The primary components of such a system are a national registration and reporting platform, indicators and baselines for each sector, and a verification system for assessing uncertainties and quality control;

(c) Advocating for the creation of a legal instrument (by-law or regulation) that will require the disclosure, on a continuous basis, of activity data by major GHG emitters to the ministry responsible for the, climate or any other relevant institution. In some cases, the establishment of new legislation was followed by the creation of a new entity responsible for facilitating coordination with stakeholders,

including the public and private sectors, while in other cases the set-up of a designated entity preceded and the entity has been working on developing a legal instrument;

(d) Documenting the steps in the data collection process and annotating collected data to help maintain institutional memory and serve as the basis for a larger data depository.

Some non-Annex I Parties are using intra-team peer review for quality assurance. For example, the agriculture team's contribution is reviewed by the energy team, and the land use, land-use change and forestry teams' by the agriculture team, whose results are in turn reviewed by the waste team, and so on. These intra-team reviews are included as a task in each team member's terms of reference.

Some non-Annex I Parties recommend a system with a minimum of two experts per sector, one responsible for entering the GHG data while the other(s) check(s) and either validate(s) or trigger(s) a recalculation. The recalculation, when triggered, is performed by both/all experts to ensure that the final results truly reflect the national GHG inventory for that sector.

Some non-Annex I Parties are working on tailoring the relevant IPCC guidelines and guidance documents to their specific national circumstances, and on training national experts across sectors in using these tailored guidelines and guidance documents in order to meet reporting requirements.

3. Best practices in GHG inventories

Regional capacity-building GHG inventory workshops on improved reporting tools conducted by the UNFCCC have reportedly enhanced the capacity of existing national experts and increased the pool of experts within a range of national institutions, as well as provided a platform for sharing experience and lessons learned. The workshops have reportedly contributed to the value clarification of national emission factors, the refinement of activity data and the analysis of GHG inventory categories.

To address gaps in activity data, some non-Annex I Parties have prepared a summary report that identifies the gaps and a template to guide national institutions with the collection of data, which have proven to be effective. By sharing these documents with the institutions concerned, some NC teams have obtained good-quality data that is complete and with sufficient detail to enable the application of an IPCC tier 2 estimation methodology for some subsectors. This has yielded good results in cases where industry actors have the needed activity data but do not want to share them because they are not required to do so.

A few non-Annex I Parties have established sectoral focal points in key ministries for data management and created avenues for improving data sharing among institutions. The sectoral focal points are also responsible for regularly monitoring and performing consistency checks on collected data, which are expected to reduce inconsistency in data sets, reviewing methodological suitability, making suggestions to revise/update the spreadsheets and performing quality control.

A few non-Annex I Parties have found it a good practice to use the Monte Carlo simulation (a tier 2 methodology) for the uncertainty assessment for key categories.

To deal with highly aggregated activity data, some non-Annex I Parties have filtered one kind of information out of another and/or created coefficients (based on expert experience) that can be used to

split aggregated information into different values, and reported positive results. Though time-consuming and labour-intensive, teams that have factored in time for such work during the planning phase have found it rewarding.

Some non-Annex I Parties have found organizing sectoral meetings on the topic of collection of information, in which activity data and emission factors are regularly discussed, to be valuable. It is recommended to accompany these activities by a centralized information system for all relevant data generated during the inventory process so as to allow a constant comparative assessment.

National stakeholder workshops focusing on providing a general introduction to the national reporting process, rather than technical meetings, have also been beneficial. As a kick-off meeting, the workshops have brought in a wide range of stakeholders, and, by introducing how the process of and the preparation of NCs and BURs is linked to their daily work, they have effectively encouraged the participation of stakeholders. The workshops could also provide a platform for discussing national circumstances and ways to enhance the data collection and management process.

For a better understanding of national GHG inventory results, some non-Annex I Parties suggest providing documentation on, among other things, activity data and underlying assumptions used and their justification. They also recommend providing information on the methodological approaches used and steps taken, as well as the sources of information on which the analysis is based, in the national GHG inventory report.

The above results cannot be extrapolated directly to Annex I Parties, although some of the points raised by non-Annex I Parties are and will remain relevant to any Party.

Three key messages arise from the richness of information reported on constraints, lessons learned and best practices:

1. The lack of legal instruments and/or policy support and resources usually result in inadequate institutional arrangements for the preparation of NCs and BURs, including GHG inventories. This also undermines data collection and quality improvements.
2. In dealing with data-related issues, countries have found it important to raise the awareness of data custodians and key stakeholders regarding data gaps and methods for data collection. Documenting these steps also helps maintain institutional memory for a sustainable reporting system, particularly when there are difficulties retaining capacity and expertise.
3. Through the scope of the national reports, countries are increasingly recognizing that the benefits of conducting national GHG inventories, as well as vulnerability, adaptation and mitigation assessments, go beyond fulfilling the reporting requirements under the UNFCCC. The information prepared for NCs and BURs has been used for national planning, international climate negotiations, and the mobilization of financing for climate change and development activities.

The above experiences within the existing UNFCCC transparency framework should be seen as valuable lessons to inform the future enhanced transparency framework under the Paris Agreement.

12. Take-home messages for NSOs

One of the priority areas identified in the Survey was to clarify and provide guidance about key issues NSOs need to know regarding GHG inventories. The objective of this short paper was both to inform and improve the understanding of the current or/and potential role of NSOs within GHG inventories. These are the key messages:

F*ormalise the role of NSOs in national systems/institutional arrangements* – This is an essential element for a good-quality and sustainable GHG inventory as it provides *certainty* about the roles and responsibilities of each institution during inventory compilation and review. It is an *internal matter* that has to be discussed in the national context. There should be mechanisms at national level to ensure *data sharing* between agencies producing activity data and other parameters used in GHG emission inventories.

Consider an integrated MRV system and know your country's climate commitments – The GHG inventory is the nuts and bolts of the MRV system and the basis for tracking national and international climate change objectives and ensuring transparency. This needs a clear division of roles responsibilities within the national GHG system, a QA/QC Programme to ensure the quality of emission estimates, and preferably, an integrated system of GHG inventories, projections and policies and measures in order to track progress towards NDCs. NSOs should also be aware of their country's climate commitments. This is important for bridging the gap between policy makers and the general public and raise the importance of data used in GHG inventories.

Aim at improving the consistency of official statistics and GHG inventories and seek closer cooperation **-** The alignment of official statistics and activity data used in GHG inventories can lead to *data quality improvements* that would benefit both official statistics and GHG inventories. One example of how this can be done is the EU Energy Statistics Regulation (EU ESR). Article 6.2 says that every reasonable effort shall be undertaken to ensure coherence between energy data declared in accordance with the EU ESR and the EU Monitoring Mechanism Regulation (EU MMR) for monitoring and reporting to the UNFCCC. Although legislation is helpful *better collaboration* between GHG inventory compilers and energy statisticians is essential for improving emission estimates in the energy sector (and other sectors as well). *Training possibilities* are available to get acquainted with UNFCCC/IPCC Guidelines for reporting and review, so that both communities speak the same language.

One useful practical way to improve collaboration is via expert workshops with the aim to a) increase the quality of GHG emission estimates and/or estimates; b) increase the cooperation between inventory compilers and statisticians in national statistical institutes; c) reduce the burden on producers of data and respondents to various data collections; and, d) increase coherence in various reports and to improve data sharing and quality. Expert workshops between inventory compilers and NSOs will ultimately improve the quality of GHG inventories and official statistics (it goes both ways).

Stepwise approach to GHG inventory improvements: Parties are at *very different levels* in relation to preparing GHG inventories. Annex I Parties have more experience with GHG inventories but it has taken many years of reporting and review to achieve good GHG inventories. Many non-Annex I Parties have used or are planning to use the 2006 IPCC Guidelines in their reporting of BURs, showing a level of ambition that goes beyond the current reporting requirements. It is a *learning by doing process*. Whatever approach and/or speed of adjustment and ambition, GHG inventories cannot be perfect but

should show *continuous quality improvements*. NSOs can make these improvements sustainable in the future by making data part of the national statistical process.

Paris agreement opens possibilities: The upcoming implementation of the Paris agreement opens new doors for all Parties in relation to how NSOs can contribute to the improvement in the quality of GHG inventories. An enhanced and global transparency framework and new data-related requirements, some of them beyond inventories, should open up larger opportunities to contribute to these processes within the various institutional roles and responsibilities agreed at national level. The ongoing process of refinement of the IPCC Guidelines is a very good entry point for NSOs to contribute directly with their expertise in data processes, including data collection and QA/QC.

13. Glossary of terms and acronyms

The UNFCCC has an extensive list of acronyms, terms and definitions related to climate change that can be looked at from its website https://unfccc.int/process-and-meetings/the-convention/glossary-of-climate-change-acronyms-and-terms

The list below includes some of the most common acronyms used in this paper

LIST OF ABBREVIATIONS

BR	Biennial report (Annex I Parties)
BUR	Biennial Update Reports (non-Annex I Parties)
CES	Conference of European Statisticians
CGE	Consultative Group of Experts
COP	Conference of the Parties
CRF	Common Reporting Format
DG-CLIMA	Directorate-General on Climate Action of the European Commission
EU	European Union
EEA	European Environment Agency
EU ETS	European Union Emissions Trading System
Eurostat	Statistical Office of the European Union
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre of the European Commission
LULUCF	Land use, land-use change and forestry
MRV	Measurement, reporting and verification

NACE	Statistical classification of economic activities in the European Community
NDCs	National Determined Contributions
NSO	National Statistical Office
NSS	National Statistical System
TACCC	Transparency, accuracy, comparability, consistency, completeness
QA/QC	Quality Assurance/Quality Control
SNA	System of National Accounts
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change