PARTNERSHIP FOR MARKET READINESS

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Supporting GHG Mitigation Actions with Effective Data Management Systems

This Technical Note (the "report") was prepared for the PMR Secretariat by the PricewaterhouseCoopers LLP ("PwC") Sustainability & Climate Change team in London, including Jonathan Grant (jonathan.grant@uk.pwc.com), Stuart Jefford, Rob Milnes and Nadia Schweimler with guidance from the PMR Secretariat.

We would like to thank the many PMR countries that provided input. The report was based on case study information from Australia, Germany, the United Kingdom, and the United States, and the report particularly benefitted from the input and feedback from those countries. Kong Chiu at the US Environmental Protection Agency (EPA) drafted the US case study. Other information and feedback was provided by Brazil, Chile, Mexico, and Ukraine, as well as from participants at the PMR Technical Workshop on March 13, 2013 in Washington DC. A list of interviewees is included in Annex G.

Comments and questions on this Note should be directed to the PMR Secretariat pmrsecretariat@worldbank.org).

For more information on the Partnership for Market Readiness, please visit: www.thepmr.org.

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Introduction

The Partnership for Market Readiness (PMR) is a global partnership, which provides funding and technical assistance to support the design and development of market-based instruments to reduce greenhouse gas (GHG) emissions. The PMR is country-led and builds on countries' own mitigation priorities. It emphasizes improving technical and institutional capacity to scale up mitigation efforts, including domestic emissions trading, crediting mechanisms and carbon taxes, among others.

Addressing essential "readiness" components applicable to all types of market-based instruments – such as monitoring reporting, and verification (MRV), data management, modeling, baseline, among other topics – is a crucial part of PMR's work to provide technical assistance. This report focuses on GHG data management systems, which refers to the technologies and processes that facilitate data collection and organization for use to meet climate change-related policy objectives.

The report contains three parts. First, it provides an overview of the types of data management systems included in this analysis – namely, systems that support (1) national level inventories, (2) facility-level reporting, and (3) carbon asset registries as well as other systems for clean energy and energy efficiency policies. The first part also provides a snapshot of four cases studies (the United Kingdom, Australia, the United States, Germany; Annexes to this report includes full descriptions of the case studies). Secondly, the report presents lessons learned from the case studies, and derives a number of key considerations for designing and developing data management systems. Finally, it proposes design principles that PMR partner countries may find useful when implementing GHG data management systems of their own.

Understanding **the Issues**

Countries face many challenges when developing systems to collect and manage GHG data. Whether reporting country-level emissions in a robust national inventory or influencing GHG emissions through policies that affect installations and facilities – such as market-based measures under the PMR – countries will need to address the following key common elements:

1. How to monitor, report and verify (MRV) data to meet policy objectives, and
2. How to coordinate systems to efficiently make use of collected data.

Once emissions have been monitored and reported by companies or facilities and, as necessary, verified, the data must be managed in a way that is valuable for regulators and policy makers to use. The purpose of this report is to provide guidance to PMR countries as they evaluate options to develop GHG data management systems. It does not provide information on methods and procedures to monitor, report, or verify GHG emissions. The guidance in this report is informed by case studies of countries that have designed and implemented their own GHG data management systems. Lessons learned are identified from these case studies and distilled into a set of design principles. This paper refers to four types of GHG data management systems, which have corresponding policies/mandates:

National-level GHG inventory reporting

Reporting information on emissions and removals of GHGs is mandated under the United Nations Framework Convention on Climate Change (UNFCCC), for all Parties to the Convention. These reports are frequently called national inventories, and referred to as "top-down" GHG inventories, as the level of emissions production is calculated using national statistics. The International Panel on Climate Change (IPCC) sets out a protocol for collecting data and reporting GHG emissions, including specific methodologies that are tailored for each sector of a country's economy. The steps involved in producing a national inventory (collection of data, estimation of emissions and removals, checking and verification, uncertainty assessment and reporting[1]) can be supported by a variety of formal and informal data management approaches, ranging from spreadsheets to tailored software. All inventory reports and biennial update reports are available on the UNFCCC website[2].

Facility-level GHG reporting
"Facility" generally refers to a physical property on which a GHG emissions source(s) is located. Facility-level reporting applies to power plants, steel mills, and cement plants, for example. In contrast to national-level GHG inventories, facility-level reporting is often called "bottoms-up." Facility-level reporting systems hold all the necessary information about organizations required for compliance with a policy. This often includes details of the staff responsible for compliance, site location, type of CO2 emitting equipment and fuels used on site, how CO2 emissions will be measured and the total CO2 emissions of the site. Details about individual facilities' emissions production and fuel use can be used to enhance national level inventories, if the data systems are designed and operated in a manner that allows for the exchange of information.

Carbon asset registry
A carbon asset registry is a system for recording the ownership of carbon permits and allowances, which can support allocation, banking and trading of tonnes of CO2. Because a carbon asset registry records property rights with a financial value, it requires security features such as authenticating access, activity, trades in order to prevent fraud. The registry needs integrity as security breaches not only undermine the owners of the property rights but also the confidence in the policy. While a policy or measure defines the market for the tonne of CO2 in the carbon asset registry, the carbon asset registry holds no information about the policy or installation other than the name and tonnes of CO2 it holds, e.g. EUA (European Union Allowance, the unit of the EU Emissions Trading System).

Reporting data for other policies related to GHG mitigation
Data management systems to support other policies, such as energy efficiency initiatives or energy consumption taxes, may also involve collecting and organizing data at the facility-level. For instance, a building owner's electricity use might be a part of the reporting program. Unless managed in a coordinated way, there is potential for multiple data management system that use facility-level data to require duplicative efforts by facility owners as well as regulators. The shading shows which of parts of the data management system are addressed in this report.

Figure 1 illustrates the components of a GHG data management system, from GHG data production through use, comprising six key steps (in boxes) and five links between them. The arrows show the links that exist between these steps, in the form of technologies and processes. The parts of a data

[1] See http://www.ipcc-nggip.iges.or.jp/public/2006gl/.
[2] See http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598.php.

management system included in Figure 1 apply to reporting programs for national GHG inventories, installation-level GHG reporting programs, or other GHG-related initiatives, such energy efficiency programs or emissions mitigation efforts a part of as National Appropriate Mitigation Activities (NAMAs). The shading shows which of parts of the data management system are addressed in this report.

Figure 1: Key Steps and Links in the GHG Data Process with GHG Data Management Systems Highlighted[3]

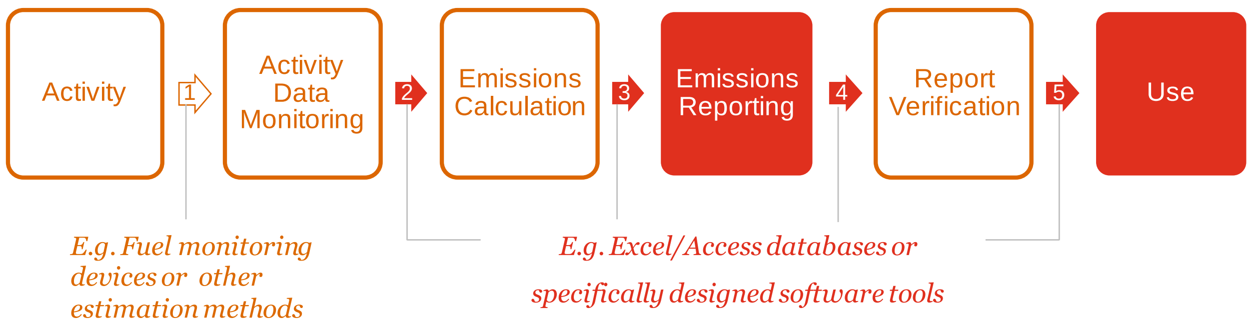


Table 1 provides a description of the steps involved in GHG data management (labeled "Box") and the connection between the steps; it also explains whether or not the steps and links are included within the scope of this report.

Table 1. Parts of the GHG Data Management Process and Relevance to this Report

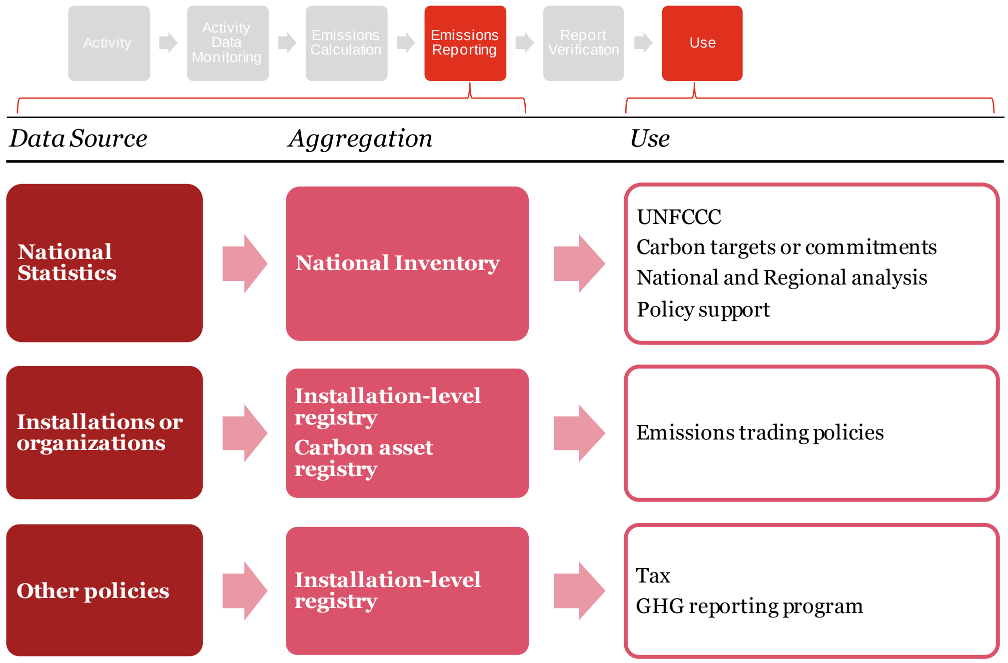
	Description	Considered as GHG data management system by this report?
Box 1	Activities giving rise to GHG production: either direct (such as combustion of fossil carbon) or indirect (such as from purchases of electricity).	**No:** Numerous and, while used to produce GHG data, not a part of GHG data management systems processes addressed in this report.
Link 1	Instruments or estimation techniques used to monitor GHG production activity.	**No:** The various monitoring devices and other estimation methods are not a part of GHG management systems processes addressed in this report
Box 2	Monitoring of activities giving rise to direct and indirect GHG emissions (part of MRV).	**No:** While used to produce GHG data, the various activities required to monitor GHG production activities are not a part of GHG management system process addressed in this report.
Link 2	How monitored data are passed for calculation, which may be automated through an online portal or may be sent in a spread sheet by email.	**Yes:** GHG data management systems must organise and aggregate monitored data so that the appropriate emissions factors can be applied.
Box 3	Calculation of GHG emissions by applying GHG emissions factors and methodologies to monitored activity data.	**No:** Done in a variety of different ways that, while supported by GHG data management systems, are not a part of GHG management system process addressed in this report.

[3] **PwC**

	Description	Considered as GHG data management system by this report?
Link 3	How calculated GHG data are passed for reporting. This may be through an online portal or through emailing of spread sheets to a central body managing a GHG database.	**Yes:** Organisation and aggregation of calculated GHG data (for example through coding by sector or type) is a key function of a management system.
Box 4	Reporting of GHG data by Government or private operators (part of MRV). This might be in annual reports or on online databases.	**Yes:** Reporting of GHG data is shaped by the structure and functionality of the data management system used.
Link 4	How data are passed to verifiers, perhaps through spread sheets or through verifiers having controlled access to an online portal.	**Yes:** Data management systems are essential for ensuring robust and trusted verification.
Box 5	Verification of the GHG data reported to provide assurance to those using it.	**No:** Activities carried out by verifiers may use and feed into data management systems (see links 4 & 5) but are not themselves a part of GHG management system process addressed in this report.
Link 5	How verified GHG data are passed for reporting. This may be through an online portal, or through emailing of spread sheets to a central body which manages a database.	**Yes:** Organisation and aggregation of verified GHG data (for example through coding GHG type and sector) is a key function of a management system.
Box 6	Final use of GHG data, such as a national inventory or a carbon asset registry.	**Yes:** Use of GHG data is heavily influenced by data management systems (for example, what detail of GHGs can and cannot be reported or influenced).

The data flow map in Figure 2 shows how data is managed from data source, through aggregation of the collected data. The top row corresponds with national GHG inventory reporting; the middle row relates to GHG reporting for programs like emissions trading systems; the bottom row represents data management for other GHG-related programs, such as initiatives that tax energy use for large electricity consumers.

Figure 2. Example Data Flow Map[4]



As shown in the next section, the level of integration and communication between data systems (e.g., for national inventory reporting and for facility-level reporting) is a key data management challenge.

[4] **PwC**

Learning from Experience – an Overview of Four Case Studies

The United Kingdom (UK), Australia, the United States (US), and Germany have experience developing GHG data management systems associated with calculating national inventories and implementing climate policies[5]. Based on their experience designing and operating data management systems, these four countries are used as case studies to provide lessons learned. The case studies are detailed in full in the annex to this report; Table 2 provides a brief overview of them.

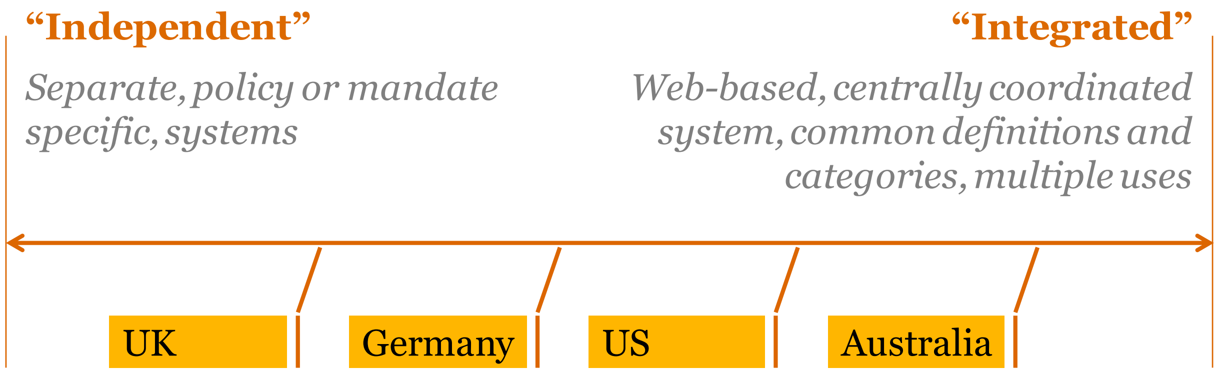
Table 2. Overview of Case Study Countries

United Kingdom	The UK started its own Emissions Trading Scheme, the UK ETS, in 2002 to target energy production. It also implemented policies to address energy consumption such as the Climate Change Levy (CCL) and Carbon Reduction Commitment Energy Efficiency Scheme (CRC) and is part of the EU Emissions Trading System (EU ETS). The UK produces a highly regarded national inventory which contains data from as far back as 1970. Effectively, the UK has separate data management systems to support its (1) national inventory, (2) facility-level GHG reporting program as part of its ETS, and (3) energy consumption policies, respectively. Figure 3 below represents the UK data management systems as "independent."
Australia	Australia established a Carbon Pricing Mechanism (CPM) from 2012-13 and is scheduled to transition to an ETS beginning in 2015. It already has data management systems in place to support the CPM, including a national reporting data system (which obligates entities to report energy production, consumption and GHGs) and a carbon asset registry. As with the UK, Australia's national inventory is well established. In contrast to the UK, data management systems supporting climate-related policies in Australia are represented in Figure 3 as "integrated." This is because the data collection methods for facility-level reporting are coordinated –i.e., a single user interface to gather information applicable to multiple policies – and the facility-level reporting system automatically provides information to increase the national inventory's detail.
United States	Similar to Australia, data management systems have preceded policy in the US. The US Environmental Protection Agency's (EPA) Greenhouse Gas Reporting Program (GHGRP) was developed to provide information for a variety of policy options under consideration. The centrepiece of the program is the electronic greenhouse gas reporting tool (e-GGRT). This tool is supported by an advanced online data map called FLIGHT which shows each facility's emissions data. The national-level inventory is also well established and has been running for 20 years. Like Australia, the data management systems in the US are shown as "integrated." The US EPA is working to improve the way that data from its facility-level reporting program informs and enhances its national-level GHG inventory.
Germany	Similar to the UK, Germany is obligated under the EU ETS Directive to implement a facility-level GHG reporting program and has a well-established national GHG inventory that complies with UNFCCC requirements. Germany uses its federal states as an intermediate data collection body. For facility-level reporting, Germany uses a web-based system designed specifically for the EU ETS. It has been updated to improve verifier access and increase security. The data management systems in Germany resemble the collection of independent systems in the UK and, therefore, tend to operate in an independent fashion of one another.

[5] These four countries were selected to provide a range of approaches, though a number of other systems – such as that managed by the EU – could also serve as useful examples.

Based on their particular circumstance, the four countries included in the case study review have ended up with data management systems that are characterized in the following way: separate, "independent" systems on the one hand and "integrated" approaches that coordinate multiple systems on the other. To differentiate between the types of data management system approaches, Figure 3 places them along a spectrum.

Figure 3: Spectrum Different Types of Data Management Systems



An "independent" data management system describes systems that are suitable for the specific policies or inventories that they serve, but which have no, or limited, links between systems. The UK, for example, developed several GHG data management systems to implement several specific policies, as well as to report its national inventory. This approach may have been adopted in an attempt to minimize the burden on reporters, because policies have been developed at different times and in isolation from one another, or due to insufficient time to integrate policy design. Independent systems are more likely to have multiple reporting timeframes for companies and require that the same or similar data is reported to different regulators.

An "integrated" data management system offers a contrasting approach, allowing for the coordination and comparison of different data sets collected for different purposes. This is achieved through structuring the data management system using common and comparable features. "Integrated" systems also provide a user interface that often enables a single point of data entry to serve multiple reporting programs. Australia analyzed data needs associated with multiple policies and considered future policy needs, as well as user interaction, to establish its "integrated" data management system.

Lessons learned

Eight lessons learned to designing and implementing GHG data management systems – drawn from the country case studies in this report—are explored below.

Agree on consistent and comparable definitions

Adopting consistent and comparable definitions of sectors and emission factors helps to align datasets, which allows for more detailed comparisons of datasets and, ultimately, better informs policy discussions. For example, the UK has experienced challenges with double counting GHG emissions between the EU Emissions Trading System (ETS) and the UK national inventory because the sectors used in the EU ETS do not match those in its national inventory. This situation has arisen in the UK because of different policy directives yielded different data management systems: international (UNFCCC), regional (European Union) and national (UK).

Consider data management system requirements from the beginning
Research and incorporate data system needs and functionality as early in the policy design process as possible. This helps to ensure that data entry, review, validation and submission to the regulator are automated to the right level.

At its simplest, a data management systems may involve the use of spreadsheet templates to collect data from reporters that are, then, sent to a regulator (via email or manually) and collated into a database. For more complex systems, this can be done using web-based portals linked to software supporting workflows to coordinate the activities of reporters, verifiers and regulators.

Experiences from Australia and the US suggest that planning for an itegrated web-based data management system can bring a number of benefits:

- Improved ability to deal with a greater number of installations, users and data.
- Ability for multiple users to access data (e.g. operators, verifiers and the central agency) with differentiated levels of access and ability to extract tailored reports in accessible formats such as spreadsheets.
- Reduced administrative burden and greater efficiency of data processing for all users.
- Automatic checking leading to increased consistency and accuracy of reporting.
- Improved ability to standardize data submissions which can result in improved quality of reporting (and therefore less time spent in correspondence).
- Reduced burden on reporters, particularly in cases where data are changed, corrected or resubmitted.
- Increased security of the system by having user log-in credentials.

Alternatively, the UK experience – moving from a *Microsoft Excel* and *Access* based system to the online system 'ETSWAP' – suggests that transitions, which are not well anticipated and planned for from the start, can be complex and require significant resources dedicated to reconciling old and new systems.

Internet infrastructure or financial constraints may prevent the use of a fully automated data management system, capable of serving multiple reporting regimes. Where this is the case, countries should plan for a transition to advanced systems if their GHG-related policies are integrated within broader, energy, sustainability, and low carbon development goals.

Data structures should accommodate present and future needs
A view shared by UK, US, Australia and Germany is that a system that can adapt to changing policies and coordinate data collected under different reporting regimes (e.g. for national inventories as well as for specific policies), is valuable, as it allows data sets to complement and inform one another. Well-designed data systems can achieve this flexibility.

Data can be consistently labeled or 'tagged' in a manner suitable for multiple reporting purposes. The additional detail that tagging provides facilitates comparisons between data sets, or reporting periods, if and when changes in scope are made. For example, the US EPA uses an Extensible Markup Language (XML) to define a set of rules for encoding documents in an accessible format for users. This allows its data management system to adapt to the changing demands of policies and measures.

The European Commission has developed a common data tagging system called eXtensible Emissions Trading Language (XETL), which would lead to compatible inventory-level permitting systems throughout Europe if implemented uniformly. The project is called the Emissions Trading Electronic Reporting Project [6] (ETERP). Such an approach is similar to the eXtensible Business Reporting Language (XBRL) developed in business, to allow comparability in financial and non-financial information between different business systems, such as occurs in the regulation of stock markets.

Germany's experience is that one efficient system for combining GHG and other air pollutant data makes national statistics more consistent and more usable for external requirements from European Directives.

Build sense checking into systems

Input errors are likely to occur when large volumes of data are submitted to a database. Undetected errors can be pervasive and undermine the confidence users have in the data quality, and therefore the policy or scheme that uses the data. The chances of such errors occurring can be greatly decreased if "sense checking" is built into the data submission process, both before and after submission. This involves creating safeguards to ensure data integrity; it can be done manually by requiring the review of submissions by a second person (e.g., two-user authentication) or automatically by creating pre-programmed requirements into data submission templates and databases.

Carbon asset registries and installation level reporting systems often require two-user authentications in order to improve security, such as with the EU-ETS and the UK's Carbon Reduction Commitment Energy Efficiency Scheme (CRC). Further, the EU ETS's ETSWAP and the CRC online portal have narrowly defined data entry fields to minimize input errors, and the CRC has in-built emission factors to remove calculation errors.

Germany has also found that sensitivity analysis checks performed automatically by data management systems improves the quality of the data. Likewise, the US has found that open source validation infrastructure can allow application of real-time range and algorithm checks to improve data quality before submission and for verification data after submission.

Create data security and integrity controls

Any system that records property rights with a financial value (such as a carbon asset registry) requires security features to authenticate access in order to limit the potential for fraud. Similar to sense checking procedures that diminish data input errors, experiences in the UK and Germany working within the EU-ETS show the need for data integrity controls, as security breaches will erode trust among the

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[6] Further information on ETERP can be found here: http://ec.europa.eu/clima/events/0050/session_iv_eterp_en.pdf

asset owners and confidence in the policy. Electronic signature and certification could be used to ensure electronic data submissions fulfill legal requirements, where appropriate. For example, to minimize the risk of fraud in carbon asset registries, electronic authentication by two different users is often enforced.

Plan and budget for continuous improvement

The experience of all case study countries suggests that improvements to data management systems will likely be required year after year in order to stay current with policy developments and to improve system functionality. This involves budgeting for system maintenance and ongoing development. In the US, for example, regulations were updated on multiple occasions to incorporate new requirements from the EPA and feedback from experts and stakeholders; developers of the supporting databases continuously adapted the functionality of the data system to the changing requirements.

The Australian government committed to investing time and money to set-up the data management systems for NGERS and OSCAR, and budget for continual system improvement with the aim to facilitate efficient data collection. The Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DCCSRTE) is responsible for annual review of the NGERS's effectiveness and regulatory burden. This has given the government regular opportunity to act on its experience running its data management systems and to refine policy, if needed.

As data systems continuously improve to meet regulatory demands, they can be transferrable between countries and regions that have similar policies and programs. Luxembourg and Switzerland have benefited from purchasing Germany's 'MESAP' GHG information system, due to comparable requirements among them. Moreover, California used the US EPA system as a basis for its facility-level GHG reporting system to support the California emissions trading system. The US EPA would not have been able to expand the use of its system, had it not updated the features to handle complex functions (as needed by California regulators).

Consider the needs of all users

Data management systems must be designed to make it as easy as possible for users – such as reporters, verifiers, regulators, or the general public – to report or use the data. Different groups of users will have different requirements and capacities to submit or use data. Ideally, potential users will have been identified early on and consulted during policy development. Part of this engagement should include discussion of what data they are currently producing for their own purposes or for existing programs, how expensive it may be to achieve the desired level of reporting, and their appetite for upgrading their data reporting practices.

One of the main advantages of Australia's National Greenhouse and Energy Reporting Scheme (NGERS) and supporting Online System for Comprehensive Reporting (OSCAR) is that it provides a one-stop shop for all components of the Clean Energy Legislative Package. Operators and installations are obliged to report one set of data to one entity once per year, with a unified MRV procedure. This makes reporting simpler and time efficient, with less scope for overlap in GHG data management systems.

US EPA needed an advanced GHG data management system because of the broad scope of its GHG reporting program and the high number of data system users. The system, which allows users to easily interact with published GHG data and locate sites on a map, uses open source Java and Javascript

Application Processing Interfaces (APIs), for example Google Maps, to power the world-class data publication website called FLIGHT [7]. Furthermore, the EPA's experience also shows that supporting the use of common data file formats, such as Excel, helps system users accept data submission responsibilities as they prefer to work with familiar tools.

Invest in user training

There will likely be a wide range of capacities and abilities among reporters. Investing in system user training, during system development as well as year after year operation, improves the quality of data submission. GHG data reporting can be a complex process and is still relatively new to organizations. Thus even with significant efforts in stakeholder engagement by the government, companies will always need some level of help when starting to report their GHG emissions.

Australia emphasized the value of investing in training reporters to improve the quality of the data submitted. In the first years of implementing the NGERS Act, the Australian Clean Energy Regulator (CER) invested in stakeholder engagement, with a particular focus on educating reporting entities. The aim was to create "empowered reporters" who are able to efficiently and correctly comply with reporting requirements. This was not only based on the belief that reporters who understand what they are reporting and how to report are in a better position to provide accurate and complete data, but also on the value Australia places on corporate citizenship.

Deciding on a Data Management Approach

In addition to identifying lessons learned, the case studies reveal several key considerations to address when designing data management systems, including

- Time (spent on design, development and maintenance)
- Cost (i.e. to commission data management systems)
- Potential to scale up use
- Burden on reporters / verifiers
- Burden on Government
- Ability to deal with multiple policies
- Ability to support tradable carbon assets
- Training and educational requirements

Table 3 applies these considerations to the "independent" and "integrated" types of data management systems (represented in Figure 3 above), and provides comments on generic advantages and disadvantages relative to the two systems. It attempts to give an impression of the particular strengths and potential weaknesses, recognizing that a more complete analysis is entirely dependent on a country's local circumstances.

Table 3: Applying Key Coniserations to Two Types of Data Manaement Systems

Particular strength	✓
Potential weakness	✗

[7] www.ghgdata.epa.gov

Key Consideration	"Independent" Data Management Systems	"Integrated" Data Management Systems
Cost	Likely to have lower setup costs. ✓	Likely to have higher setup costs. Likely lower cost to implement future policy changes.
Time to implement	Separate data systems can be set up as needed and in tandem with policy and NAMA development. ✓	More time is needed up-front to identify data requirements of separate policies and engage with a greater number of users. This may delay implementation of policies and NAMAs. ✗
Reliability of data in system	Cross checking between systems is more time consuming and less reliable. ✗	Ability to cross check between data sets collected for different purposes and to provide complementary detail. ✓
Burden on reporters / verifiers	Increased likelihood that the same data must be reported by the same firm to different regulators. ✗	Lower burden as data only needs to be reported once into the system. ✓
Burden on Government	Difficult to aggregate and manipulate data. ✗	Easy to aggregate and manipulate data, easier to compare between data sets (i.e. to provide additional detail or to sense check). ✓
Potential to scale up use	Additional capacity may be required by systems if schemes or policies expand, this would risk a transition period. ✗	Advanced systems likely to have a greater capacity for data.
Potential to develop increased functionality	Likely to be low and difficult to implement. ✗	Likely higher to add automated work flows with reminders to users. Likely higher to add different functionality for different users. ✓
Ability to deal with multiple policies	Different systems required, may be appropriate for smaller scale policies and measures.	Single reporting for all. ✓
Ability to support tradable carbon assets	More advanced systems required for a trading registry which tends to be separate from other systems because of security needs	More advanced data systems will be required for a trading registry which tend to be separate from other systems because of security needs
Training and educational requirements	Simple and familiar data management systems. Separate training likely required for each system and any upgrades. ✗	Increased complexity of system likely to increase reliance on external subcontractors, limiting capacity building in government. Single system requires less training. ✓

Differences in local circumstances mean that PMR countries will assign different priorities to the "key considerations", and may include others. Having identified a set of their own priorities, PMR countries can use Table 3 to indicate whether their priorities lean toward an "independent" or an "integrated" approach and to guide further analysis to consider the tradeoffs and interdependencies between considerations.

How countries resolve trade-off will depend on the particular circumstances of the country and the current status of issues such as data reporting, local sector characteristics and the level of ambition within that country. The following key considerations came up frequently during the case study research and so are explored further.

- **Cost** and **time** are key considerations when deciding which type of approach to pursue. It seems that “independent” systems are likely to benefit from lower setup costs compared to an “integrated” system, although operating multiple “independent” systems may impose higher costs in the long run. Similarly, “independent” systems can be commissioned and implemented more quickly, compared to an “integrated” system, since they are likely to be less complex and require fewer data users to be consulted. These trade-offs in cost and time are likely to be influenced by a country’s circumstances, including the amount of, and duration of, available funding and the ambition of climate policy in that country. Whichever approach is pursued, there may also be the potential to reduce costs by adopting systems already developed elsewhere by countries that have similar priorities.

- **Reducing burden on reporters / verifiers** depends entirely on the local situation. An “independent” system may be able to target specific, completely separate entities to support policies rather than take a broad sweep of many organizations. On the other hand, while an “integrated” system may obligate more entities, each only has to comply once per year to the same authority. The risk posed by an “independent” system is that the reporter burden (in terms of time and cost) will be higher since same entity will be required to report similar information several times per year to different authorities. This may also have further impacts to other considerations such as data reliability and timeliness, as well as the comparability of data from different sources.

- **Potential to scale up** a system is relatively unlimited with a fully integrated system, as demonstrated by the nearly 1,000 installations submitting large amounts of monitoring and reporting data under the UK’s ETSWAP system and the 8,000 facilities using the EPA FLIGHT system. However, if the scope of the policy always remains small then upfront investment in an unnecessarily sophisticated system will be wasted.

- **Ability to support tradable carbon assets** is likely to require a completely separate system, which includes robust controls (of the level required in a finance system), regardless of the data management system used for permitting details and monitoring emissions. This means that if a country’s priority is to generate tradable carbon assets, an “integrated” web system may not automatically be the best solution for data monitoring and reporting. However, a secure and functional ICT system will be needed for the carbon asset registry, which may be separate from the monitoring and reporting system.

Given the lessons learned described above, on balance there are more strengths in the “integrated” system and more potential weaknesses with “independent” systems that risk hampering future ambition. It follows that countries are likely to have more to gain from adopting an “integrated” system, but that this will require additional planning.

Conclusion: Design Principles

In conclusion, eight principles for the design of GHG data management systems have been distilled from the lessons learned and key considerations. These principles apply equally regardless of whether an "independent" or "integrated" approach is taken. Although they focus on data management systems and MRV, the design principles are consistent with the five 'indicators of inventory quality' proposed by the IPCC in its 2006 Guidelines for National GHG inventories [8] as well as the characteristics of good GHG data defined by others [9, 10].

Use consistent and comparable definitions and categories

There are well established definitions of emissions sectors and methodologies for emissions calculations. Data management systems should draw on these and apply them clearly and uniformly. For example, the emissions sources that are in scope for different policy uses should be clearly labeled and coded in data management systems (sector, calculation method, etc.). This will allow data sets to be 'cut' in different ways and will help ensure that GHG reporting is consistent over time, and comparable with reporting from other countries or reporting initiatives.

Begin with the end in mind

Ideally, the priorities relevant to GHG data collection that exist across Government should be considered, in order to make sure data management systems are sufficiently adjustable to provide for, and benefit from, possible overlaps in policy. This may include making systems more adaptable to changes in data requirements expected to result from forthcoming domestic or international policies.

Robust data systems pay dividends

If the users of GHG information are not confident in the robustness of the data, then they will not trust it for their decision making. The level of confidence required by users of GHG data will differ depending on how material [11] the data are to them. Materiality will be driven by what the data are used for, and the relative size of potential errors or misstatements. For example, tradable carbon assets recorded at an installation level in registries are worth money, attract investment and may need to satisfy fiduciary requirements. So, data management systems that support such registries may need to provide a high level of confidence among users. Other GHG reporting, such as sector-level reporting used for government decision making, is unlikely to be directly linked to investments and small inaccuracies may have proportionately less of an impact. A data management system should support an appropriate level

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[8] These are consistency, comparability, completeness, accuracy and transparency. A full explanation can be found here: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf

[9] The World Resources Institute (WRI) characterizes high quality GHG data as being accurate, complete, transparent, consistent and verified: http://pdf.wri.org/designing_a_us_ghg_emissions_registry.pdf

[10] The European Commission defines eight 'Monitoring and reporting principles'. These are completeness, consistency, transparency, accuracy, cost effectiveness, materiality, faithfulness, and improvement of performance in monitoring and reporting emissions. These are set out here: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2004/l_059/l_05920040226en00010074.pdf

[11] The concept of materiality is useful in determining whether or not the GHG emissions are of significant quantity or not. For a specific definition of materiality referring to GHGs emitted by organizations, see the Global Reporting Initiative definition here: https://www.globalreporting.org/reporting/guidelines-online/TechnicalProtocol/Pages/MaterialityInTheContextOfTheGRIReportingFramework.aspx

of confidence, including: being materially complete and accurate, being verified by independent third parties where necessary and being sufficiently secure (see below).

Build security into GHG registries
High security standards should be set for tradable carbon assets recorded in registry systems. GHG credits are financial assets and so registries are susceptible to fraud. Registries of GHG credits require the same level of security as financial systems would, such as restricting access to approved users, password protection, segregation of duties between data entry and trading carbon assets and verification, etc. Even within an integrated data management system, data and security controls can be compartmentalized so as not to apply the highest levels to all data in the management system, preserving cost effectiveness.

Create clear, transparent governance structures
Establishing a single, responsible entity to oversee GHG data management will help to build trust among reporters as it will reassure them that the information they submit is used efficiently and in an integrated manner. Among other data users (including those purchasing carbon assets) it will provide clear accountability for data integrity.

Engage with the right stakeholders during design and development
Identify which stakeholders need to be consulted at each stage (policy makers from across government, regulators, companies, database specialists, lawyers, etc.) and invest time in understanding their needs.

Invest in training and educating data reporters
The better a company understands why and how they are reporting, the more likely they are to submit accurate and usable data.

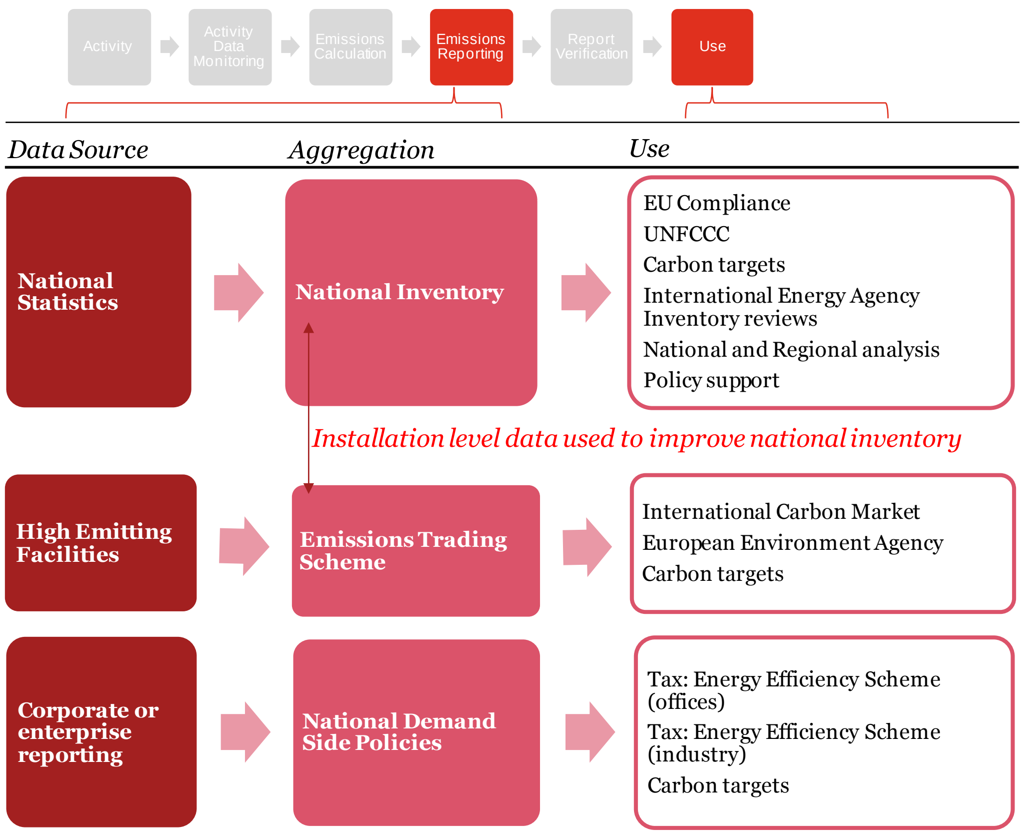
Consider data systems' role across the range of MRV activities
Regardless of how advanced, each element of a MRV program is likely to be supported by a data management system. Selecting the appropriate system functionality will help to achieve value for money and good usability. International collaboration, such as through the PMR, will help identify whether existing infrastructure or systems can be shared between countries.

Annex I: United Kingdom Case Study

Description of the current systems

The UK approach to establishing its emissions data management systems reflects the needs of national policies and Directives from Europe. These policies and Directives were introduced over time in several stages, driven by different purposes and targeting different sectors. This meant that data management systems have been developed specifically for each policy, placing it towards the "independent" characterization of data management systems. Figure 4 summarizes how data flows in the UK from a variety of sources to a variety of uses, using the same three stages (source, aggregation and use) as proposed in Figure 2.

Figure 4: Map of the UK Data Management System



The inventory is compiled in line with UNFCCC guidelines and therefore uses energy balance data where possible, compiled by the Digest of UK Energy Statistics (DUKES [12]), complemented by information on agriculture and waste emissions.

Other major greenhouse gas data management systems in the UK are driven by national and European Union (EU) policies, such as the CRC and CCL targeted and energy consumption and the EU ETS for

[12] See website here: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes

industrial process emissions and energy production. Renewable energy generation is monitored through an obligation on energy suppliers to produce a certain percentage of energy output from renewable sources, the Renewable Obligation (RO). The RO energy data are additional to DUKES and has an independent registry. Energy suppliers may produce their own renewable energy to meet their obligations or buy renewable energy from large scale projects through long term contracts with renewable energy developers or at Renewable Obligation Certificate (ROC) auctions.

GHG data reported are usually used in more than one way. For example, all of the data systems shown in the data flow map in Figure 4 are not only used for the inventory or their associated policies, but also to inform how much carbon the UK emits in a set period against its carbon targets: the carbon budgets. Further, the inventory provides data for policy impact assessments, and EU ETS data are used by the European Environment Agency (EEA) to compare GHG emissions across sectors and Member States [13] of the EU.

Coordination of data management systems

There is some coordination between the Environment Agency and other government departments of data between the different data systems in the UK. The data systems that enable reporting against the EU ETS, the EU directive on air pollutants: the European Pollutant Release and Transfer Register (E-PRTR) and CRC policies help to provide the various locations of emissions in the national inventory for an emissions data map.[14] One map is produced each year following the publication of the inventory and provides emissions of CO2 and various pollutants at a 1x1 km resolution.

Where a sector is entirely covered by the EU ETS, its emissions can be compared with DUKES data. DUKES are notified of discrepancies and in instances where the EU ETS data are higher than DUKES data, due to different methodologies, the EU ETS data may be used in the inventory.

Overlap between GHG data management systems and MRV

Where EU ETS facility-level information is deemed representative and more accurate than DUKES it provides the emission factors used in the inventory. This is driven by the EU Monitoring and Reporting Regulation which encourages the highest level of accuracy possible, which comes from on-site monitoring of fuels and gases. The most important example of this is for natural gas, where the National Grid gas company provides emission factors taken from monitoring points in its transmission grid for use in the inventory.

Challenges

Avoiding double counting

The main difficulty in providing the data map for the inventory is to avoid double counting emissions.

[13] See EEA website here: http://www.eea.europa.eu/data-and-maps/data/european-union-emissions-trading-scheme-eu-ets-data-from-citl-4

[14] UK Inventory Data Map: http://naei.defra.gov.uk/data/map-uk-das?pollutant_id=2

Double counting is a common problem in the energy sector when dealing with policies that address power generation on the one hand, and electricity consumption on the other. For example, by directly pricing on carbon emissions the EU ETS encourages power generators to be more efficient, while policies that address electricity use, such as the UK's Climate Change Agreements, tries to make business behave in a more energy efficient manner and thus reduce emissions. In doing so the same emissions - those from power generation - are reported by two separate entities. There is good reason for enforcing this: to encourage reporting and therefore management and hopefully reduction of emissions by both sides. However, if this overlap is not considered in the design of data management systems it makes comparisons difficult, and therefore limits how useful the data can be (see lessons learned).

Reconciling differences, maintaining credibility

In being part of the EU ETS, the UK has emissions data which can be used to check its national inventory. But, the EU ETS and UNFCCC define sectors differently, which must be aligned before datasets can be compared. Once sectors are aligned, the UK tries to compare EU ETS and UNFCCC sector totals where possible each year.

In some sectors it is not possible to compare EU ETS and inventory sector totals, as not all of the installations in the sector meet the qualification criteria for the EU ETS. A good example of this is the health sector, where the variety of services and related facilities mean the proportion of emissions covered by the EU ETS would be very difficult to determine.

Changing systems

In the build up to phase III of the EU ETS in 2013, the UK moved from a *Microsoft Excel* and *Microsoft Access* database system to an online system for issuing EU ETS greenhouse gas emission 'permits' (which area, effectively, licenses for GHG emitting equipment). The online system, the Emissions Trading System Workflow Automated Process [15] (ETSWAP), records site details as well as how installations plan to monitor emissions – this is an example of installation level reporting defined in Section 2 of the main report.

The UK minimized inconvenience to operators by migrating the *Microsoft Access* database information to the online ETSWAP system, though the transition did lead to some data errors that the UK Government team had to correct. The change required operators to learn a new way of applying for permits through ETSWAP rather than updating their excel spreadsheets, with which they were familiar. Finally, ETSWAP was expensive Information and Communications Technology (ICT) contract and its direct maintenance costs are higher than the *Microsoft Access* database. However, there are of course multiple cost savings in terms of user time which may outweigh the direct costs to government.

The transformation to ETSWAP for issuing permits caused confusion for operators. The transition coincided with the transition of the UK carbon asset registry to the Community Independent Transaction Log [16] (CITL), so two new web portals were introduced at the same time. In theory, ETSWAP could be linked to the carbon asset registry (often referred to as a trading registry) used. For example, in a simpler system the online portal for ETSWAP could encompass the installation description, monitoring

[15] ETSWAP can be viewed here: http://www.environment-agency.gov.uk/business/topics/pollution/134073.aspx
[16] CITL can be viewed here: http://ec.europa.eu/environment/ets/

procedures and emissions calculation and be used for buying and selling allowances. However, with 31 countries using different permitting systems, linking them all to a central trading registry is not feasible.

Lessons learned
In facing the challenges above the UK case study presents the following lessons:

1. ***Define consistent and comparable definitions*.** Consistent and comparable definitions for a data management system save time and effort and lead to more credible datasets, more detailed breakdowns of datasets and can ultimately better inform policy and the public. For example, deciding which industries are included within the definitions of different sectors of the economy; or whether emissions from energy production are assigned to the producer or to the end user of that energy (a decision that will likely depend on whose behavior the policy is targeting). Whilst future changes in policy may impact these, clarity over the definitions that already exist will make such changes easier to implement.
2. ***Consistent and comparable data tagging can bring added benefits.*** An online system that can coordinate data collected under different reporting regimes (e.g. for national inventories as well as specific policies) is highly valuable as it allows data sets to complement and inform one another. This either requires there to be consistency in categories and definitions (see lesson 1 above), or else for there to be reconciliation agreed between the categories and definitions laid out under different regimes. Data can then be consistently labeled or 'tagged', and this tagging structure used for all purposes. Where reporting regimes do differ, this approach may lead to some data tags that are not always used for all policies. But, the additional granularity in reporting that such tagging allows will mean that Comparisons can be made between data sets, or reporting periods, when changes in scope are made. As described this is not yet possible between the UK permitting and trading systems for the EU ETS, but could be in the future. The European Commission has developed a common data tagging system called eXtensible Emissions Trading Language (XETL) which would lead to compatible permitting systems throughout Europe if implemented uniformly. The project is called Emissions Trading Electronic Reporting Project [17] (ETERP). This is approach is similar to the eXtensible Business Reporting Language (XBRL) developed to allow comparability in business information between different business systems, such as occurs in the regulation of stock markets.
3. ***Plan for continued improvement*.** Improvements to data management systems are required year on year in order to stay abreast of policy developments and improve user functionality. Funding for maintenance should be accounted for and provided by each government ministry which uses the data.
4. ***Take care when reconciling datasets and filling gaps in data.*** Datasets generated to report against policies targeting a certain proportion of sectoral emissions will be incomplete if used for other purposes with different sectoral coverage. For example, using EU ETS data to provide a geographic breakdown for the UK's national inventory leaves gaps in some sectors such as health. These gaps may be filled using proxy data - such as using national employment statistics to apportion the total emissions in the health sector into different regions - although the

[17] Further information on ETERP can be found here: http://ec.europa.eu/clima/events/0050/session_iv_eterp_en.pdf

limitations to such approaches must be acknowledged (this approach, for example, assumes constant GHG intensity per employee within sectors, which may not hold given the variety of services and related facilities in the health sector).

5. ***Go online.*** An online system brings the following benefits:

    - Improved ability to deal with more installations and data.
    - Ability for multiple users to access data (e.g. operators, verifiers and the central agency) at the same time, with differentiated levels of access and ability to extract tailored reports in accessible formats such as spreadsheets.
    - Reduced administrative burden for all users.
    - Increased automatic checking and therefore quality of reporting.
    - Improved ability to standardize data submissions which can result in improved quality of reporting (and therefore less time spent in correspondence).
    - Increased security of the system by having user log-in credentials.

6. ***Think about ICT early*.** ICT should be engaged and implemented as early as possible (especially for big schemes, where there are enough facilities to make manual inputting of data submissions onerous and expensive) provided that an adequate internet infrastructure is in place, to avoid transition between systems in the future.

Annex II: United States Case Study

Description of the current systems

The US compiles its national inventory using national statistics under the UNFCCC guidelines and also has a separate reporting program with underlying data system. The reporting program is part of the Greenhouse Gas Reporting Program (GHGRP) and was recently developed to provide information for a variety of policy options under consideration. The centerpiece of the Environmental Protection Agency's (EPA's) integrated data management system under the GHGRP is EPA's electronic greenhouse gas reporting tool (e-GGRT). While the inventory is generally compiled using national statistics, facility level data collected through the GHGRP has been integrated into the inventory, where appropriate, and is also used for quality assurance and quality control.

The national inventory and GHGRP are both managed by the EPA. The inventory has been established for 20 years while the GHG reporting program was developed in 2008 with the first full year of data collection in 2010. Table 3**Error! Reference source not found.** summarizes how GHG data flows in the US from a variety of sources to a variety of uses.

Table 3: Map of the US Data Management System

Data Source	Aggregation	Use
National Statistics, Models and EPA Voluntary Programs[18]	National Inventory	• UNFCCC Reporting • National-level analysis (e.g. review of emissions trends) • Policy support
Facilities and Energy Suppliers (Industry)	National Greenhouse Gas Reporting Program	• Compliance with Greenhouse Gas Reporting regulations • National, regional, state analysis • Sectoral analysis • Policy support • Improvements to National Inventory

The direction from the US Congress was that the GHGRP should cover emissions from all sectors of the economy. It achieves this by targeting waste, industrial process emissions and emissions from power generation as well as the GHG emissions potential of industrial gases and fossil fuels supplied from upstream into the economy. This means it does not require end users of energy such as offices and households to report.

All electronic aspects of facility management, source categories, specific data requirements and annual report submissions were specified in detailed technical requirements documents prior to development of the system. The electronic data system uses a web portal (an online system) to collect GHG data from approximately 8,000 reporters across 41 source categories, including both direct emitters and upstream supply.

Each facility or supplier can log into EPA's centrally coordinated e-GGRT, select the source categories it is reporting under, enter or upload their data, review their data and then submit it to the EPA. Data is stored in a central data repository where electronic tools are used to perform standard checks on the data and process it for publication. Data is published through an interactive website known as the 'Facility Level Information on Greenhouse gases Tool' (FLIGHT). The comprehensive nature of the data collected and published supports the uses listed in Figure 5.

Inventory
National statistics data, for example fossil-fuel energy consumption data compiled by the US Energy Information Agency is used in developing the national inventory. Agricultural models and soil carbon models are used to complement national statistics for more complicated calculation methods used for Land Use Change and Forestry. Further, voluntary programs, such as the EPA Landfill Methane Outreach Program support sector estimates. Data and knowledge from the US National Inventory were critical to the design and development of the GHGRP.

Use of systems to support policy
Although the national data system was designed without a specific policy for its application, its ability to support policy was demonstrated in its "cloning" by the Californian regulators for their state regulation. The Californian regulation includes both mandatory GHG reporting (begun in 2009) and emissions trading aspects. Some modifications were required to make the EPA system suitable for California, but the EPA's underlying centrally coordinated e-GGRT data structure and system architecture are the same as used in California. This includes components of the web-based interface, how data is captured and stored in the database and the flexibility in application to incorporate additional data elements.

The Californian e-GGRT (also known as "Cal e-GGRT") helps the Californian regulator to integrate its GHG data collection efforts under its emissions reporting program with the EPA's program. Beginning with the submission of 2011 data, the Californian regulator's annual GHG data reporting methods began to align with many of EPA's requirements. Primary areas where the programs differ are in reporting of transportation fuels (Cal e-GGRT reporters are the terminal racks and not refineries to ensure an accurate reflection of the consumption of the local market), and also imported electrical power entities. Cal e-GGRT also requires reporting some supplemental data not currently collected by EPA.

Coordination of data management systems

For some emissions sources, comparisons can be appropriately made between the new GHGRP and the US Inventory of GHG Emissions and Sinks. However, while the GHGRP covers the vast majority of emissions from covered source categories, reporting thresholds under the GHGRP exclude smaller, low-emitters which limits its coverage and therefore comparability with the inventory for other sources of emissions. This is also an issue in Europe, as seen with the UK. Additionally, differences in source category definitions exist between the internationally accepted definitions used in the inventory, and the definitions developed for U.S. facilities by the GHGRP. These differences limit comparability between the two programs for some emissions sources. The EU ETS covers approximately 45% of greenhouse gas emissions in its 31 member countries, which can be compared to the GHGRP which covers approximately 85 to 90%, of the US inventory total.

It is possible that having the GHGRP successfully implemented and data collection and analysis started, the data and knowledge from the GHGRP can be used to improve the National Inventory.

Using existing systems from different states
When the US EPA finalized its Mandatory Reporting of Greenhouse Gases Rule, more than a dozen states already had, or were in the process of, implementing their own greenhouse gas data collection programs. As part of its commitment to work with states to harmonize data systems and reduce reporter burden, the EPA launched a State-EPA Integrated Project Team on GHG data collection and exchange in 2010. Development of the Californian e-GGRT was a product of this effort.

Challenges

Reconciling data from different systems
To comply with the GHGRP and the Californian AB32 program, facilities in California report separately through the national e-GGRT and the Californian e-GGRT. The different reporting requirements of the two systems, such as timeframes and the level of company details needed, led to several issues with gaining comparable data, summarized below.

- Different employees within the same firm were completing the different submissions and interpreting the requirements in different ways.
- GHGRP uses EPA verification through automatic checks, statistical analysis and other analyses, but AB32 requires third party verification as well as automatic checking.
- Data for AB32 benefits from an opportunity to improve GHGRP data, which is submitted earlier in the year.
- Reporting standards under both programs have improved in the last two years and the reporters are becoming more familiar with the systems. This has reduced the variation between the two datasets to less than 5%.

Unable to build on and improve existing systems

As discussed earlier, California began to align its reporting requirements with EPA's GHGRP in 2011. California's previous system (based on the Emissions and Allowance Tracking System (EATS), a generic registry and emissions reporting system sponsored by the EPA, was much less flexible and had few options for user interfaces. CARB therefore decided not to continue using the EATS-based system for new data in 2012 and moved to modify the EPA e-GGRT system to handle future GHG reporting requirements. The old system was kept in operation during the transition.

Ensuring up to date templates are used

Facilities can upload their data onto the Californian e-GGRT using Microsoft Excel XML (eXtensible markup language) templates. When templates are updated or improved, the Californian regulators use a template version control function in Cal e-GGRT to ensue all reporters use the latest template. Data validation messages identify if users are attempting to use an old template.

Lessons learned

1. ***Electronic reporting*.** Electronic reporting, submitted online where possible, should be used for all reporters to submit data, review data, provide data validation and submit to the regulator. Online systems that reporters use to submit information to a regulatory database allow regulators to extract tailored reports in accessible formats, such as spreadsheets. Electronic reporting when first proposed by EPA in 2009 was justified based on a variety of benefits, including easy scalability of users and facilities, improved efficiency of data processing, improved consistency and accuracy of data through real-time data quality feedback and reduced burden on reporters, particularly in cases where data is changed, corrected or resubmitted.

2. ***Evidence the authenticity of reporting*.** Electronic signature and certification (CROMERR) should be used to ensure electronic data submissions sufficient legal weight where this is required, such as for producing registries of carbon assets.

3. ***Quality data begins with quality submissions*.** Significant investment in reporter support and automated, instant feedback to users before data is submitted increases quality.

4. ***Learn from your reporting systems*.** Close interaction of regulatory development and ICT system development can result in better regulations.

5. ***Be flexible in your approach to data management*.** Developers of the databases supporting the EPA had to be innovative and adapt to changing regulatory requirements by keeping in regular contact with the EPA and other experts.

6. ***Make it easy for reporters*.** Microsoft Excel document upload is easier for users than web portals. The functionality for uploading should be available, and tailored templates should be made for different groups of reporters to simplify their requirements. This can be done by hybridizing web-forms with *Microsoft Excel* based forms using 'smart-form design', allowing *Microsoft Excel* data to be easily passed and mapped into databases.

7. ***Build in the ability to sense check before and after submission*****.** Use of open source validation infrastructure can allow application of real-time range and algorithm checks to improve data quality before submission and verify data after submission.

8. ***Make it easy for users to interact with GHG data****.* Integration of open source Java and Javascript Application Processing Interfaces (APIs), for example Google Maps, to power a world-class data publication website [19] can allow users to easily interact with published GHG data.

9. ***XML gives for a flexible system which can also be added to.*** Extensible Markup Language (XML) defines a set of rules for encoding documents in an accessible format for its users and for computers. This allows a data management system to more easily adapt to the changing demands of policies and measures.

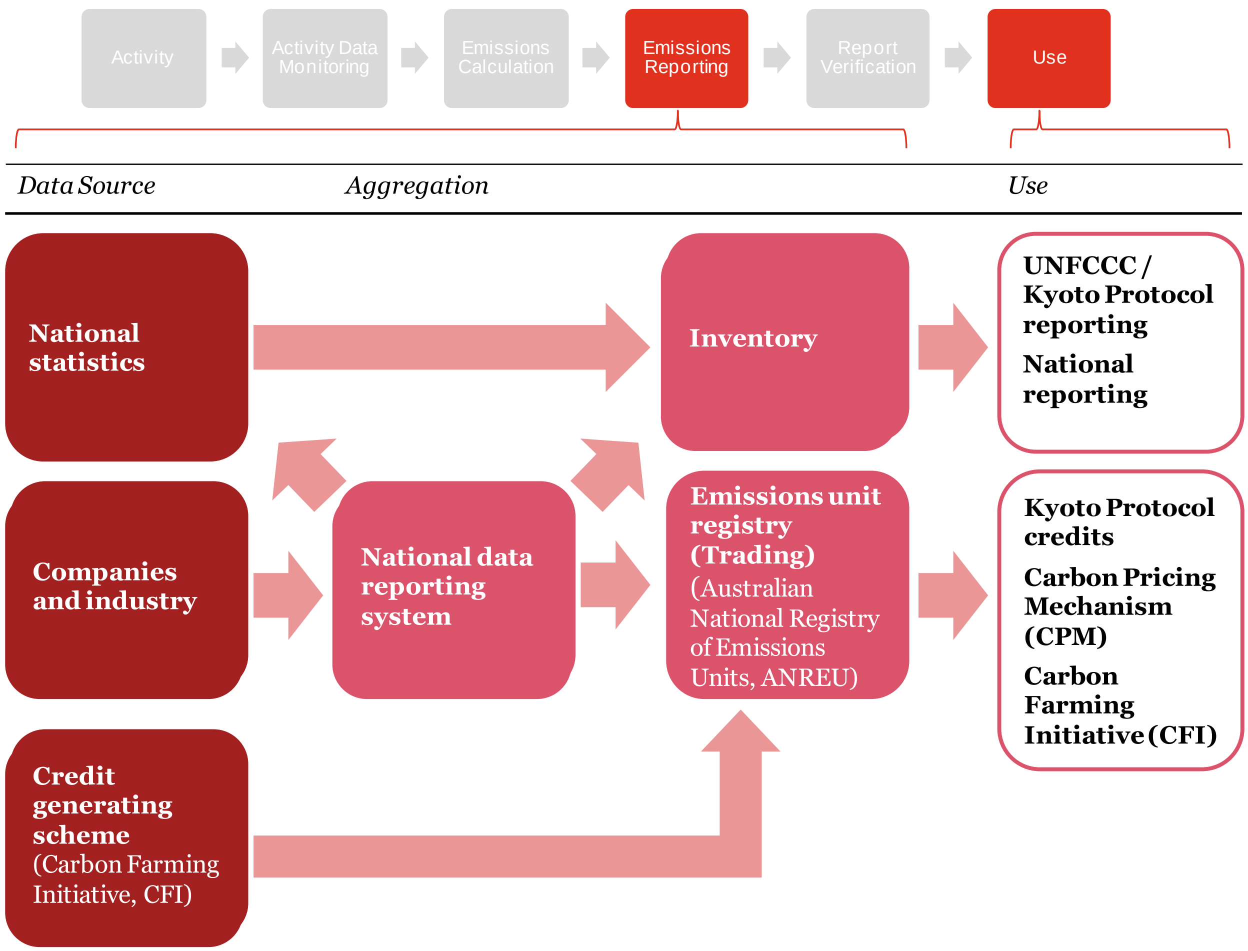
[19] www.ghgdata.epa.gov

Annex III: Australia Case Study

Description of current systems

Australia compiles its national inventory using national statistics under the UNFCCC guidelines and also has a separate reporting program with a supporting online national data reporting system, as in the US. Installation and corporate level reporting is covered by the National Greenhouse and Energy Reporting (NGER) Act (otherwise known as the NGER Scheme or NGERS). In contrast to the UK, the NGERS and supporting Online System for Comprehensive Reporting (OSCAR) were designed before the Carbon Pricing Mechanism was introduced but with the structure and data demands of possible future policies and the inventory in mind. To achieve this NGERS collates data on emissions, energy consumption and energy production for organizations above set thresholds.

Figure 5: Map of the Australian Data Management System



Inventory

The inventory is managed by a dedicated GHG inventory team in the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE). The inventory itself uses an online system named the Australian Greenhouse Gas Emissions Information System (AGEIS), which collates data on the energy, industrial processes, waste and agriculture sectors and applies national emission estimation models. The three primary GHG data sources used for the inventory are provided below.

1. National statistics, e.g. energy balance information from agencies such as the Australian Bureau of Statistics.

2. NGERS, through its associated ICT system OSCAR, supplies installation level data (GHG Protocol [20] Scope I and II GHG emissions, energy consumption and production) from operators over specified thresholds.

3. The Full Carbon Accounting Model (FullCAM) for land use, land use change and forestry collects and processes satellite image data, along with land management and soil metrics, and applies calculations to estimate CO2 flows between land sector carbon pools and the atmosphere.

The functionality of the AGEIS allows the government to meet its own policy requirements and also inform other data users such as companies, verifiers and the public. Specifically, AGEIS is able to achieve this through the features listed below.

1. Public database: it provides an online platform which makes aggregated, anonymized data publically available in a searchable database.

2. Data post processing: DICCSRTE is able to perform quality assurance and quality control checks on the data submitted.

3. Storage: it provides a place for long term, secure data storage of the national GHG accounts.

Policies
Under the Clean Energy Future Plan, Australian policy makers have legislated the policies below.

- The Carbon Pricing Mechanism (CPM), which started with a fixed price from 1 July 2012 and transitions into a fully-flexible emissions trading scheme from 1 July 2015.
- The Carbon Farming Initiative (CFI), which provides incentives to reduce emissions from the land sector[21].
- The Renewable Energy Target.

NGERS supports the implementation of these policies through the collection and reporting of energy and emissions data. Units from the CPM and CFI are managed by the Australian National Registry of Emissions Units (ANREU) – the emissions unit registry.

[20] See the GHG Protocol Scope definitions in chapter 4 here: http://www.ghgprotocol.org/files/ghgp/public/ghg-protocol-revised.pdf
[21] The CFI is a crediting mechanism whereby farmers and land managers can earn carbon credits by storing carbon or reducing GHG emissions from land use. These credits can then be sold to those wishing to offset their emissions. More information is available here http://www.climatechange.gov.au/cfi

The Clean Energy Regulator (CER) is responsible for the implementation of, and data collection for, each of these measures and disseminates the aggregated data from NGERS to government departments as needed. Data collection for policies is coordinated to reduce redundant data collection efforts and allow for synchronized reporting of both producers and consumers of energy. This is achieved through NGERS which has consistent reporting definitions and a single reporting system and online database (OSCAR).

Other uses
ANREU has been set up to manage several forms of emissions unit. This central emissions unit registry and the experience from its implementation may provide for a smoother transition to any prospective linked scheme, such as with the EU ETS. As in the UK, collating greenhouse gas information is also used in policy impact assessments.

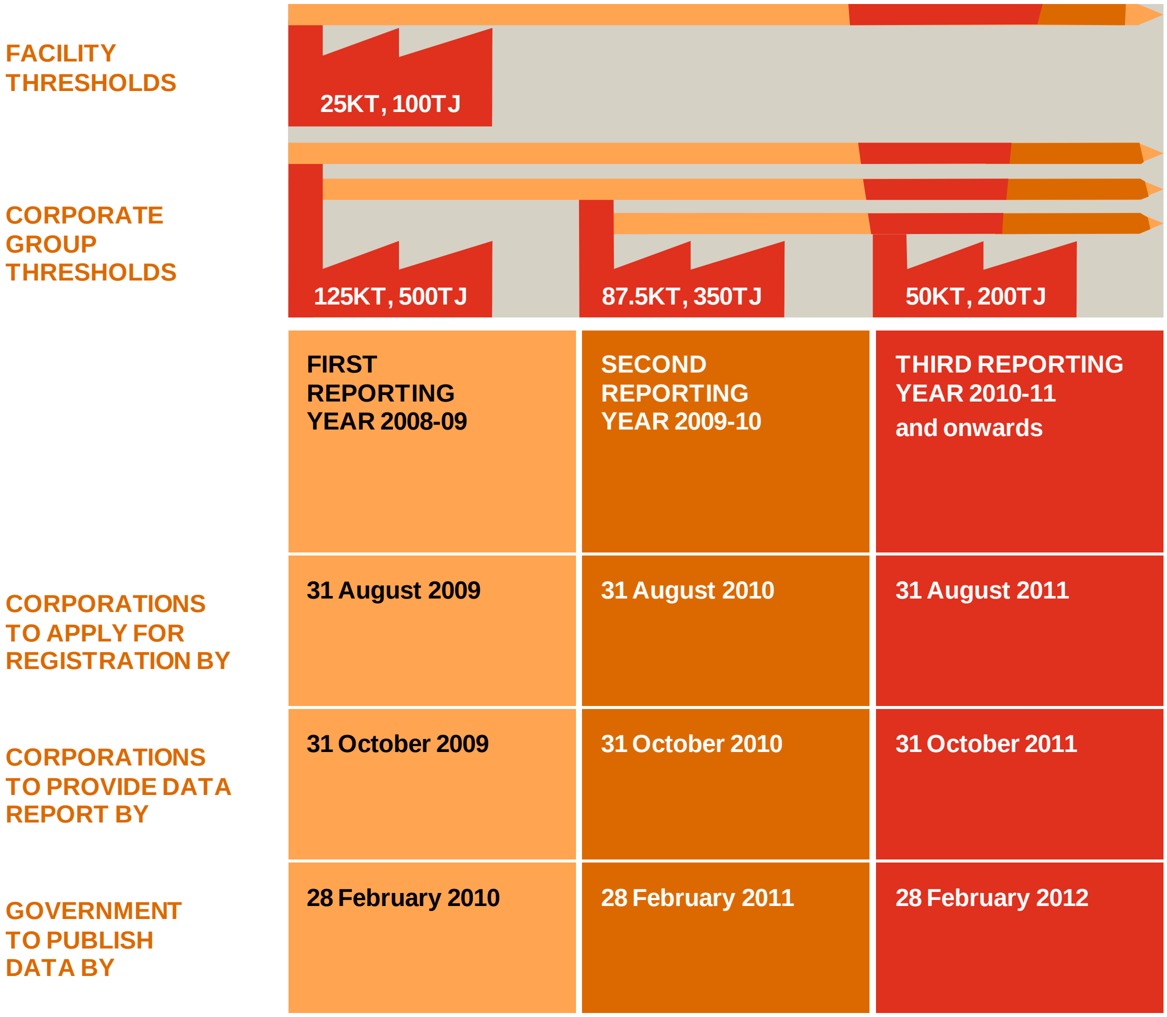
Coordination of data management systems
OSCAR (as part of NGERS) and AGEIS were designed to be compatible with one another so that site level data from OSCAR could inform the inventory. The CER manages the data submitted under NGERS and the Carbon Farming Initiative, which is used to implement the Carbon Pricing Mechanism and the emissions unit registry, ANREU. Finally, ANREU supports all the emissions units in use such as those generated under the Carbon Farming Initiative and those needed to meet Kyoto Protocol obligations.

Aggregation at the national level
Under NGERS, activity data are reported by sites and organizations directly to the national level, omitting subnational governments as intermediaries. The decision to make a direct link to the national level reporting database avoided the possibility of different standards and timings being used by subnational governments which could lead to incompatible reports. This was based on experience from other countries, learnt through Australia's role as UNFCCC Expert Reviewer of countries' GHG data collection methods.

Lessons learned

1. ***Target the biggest entities first before bringing in others*.** Like the CRC in the UK, NGERS sets de minimis thresholds above which operators are obligated to comply. In order to increase the coverage of NGERS, Australia has set provisions for the thresholds to fall every year. This means initially only those organizations or facilities with higher emissions (assumed to have a greater capacity to introduce new reporting procedures) will be required to report. Further, the regulator can use the first year to work with the larger organizations to improve their own systems before extending the requirements to smaller emitters which will be included in future years.

Figure 6: Illustration of Annual Lowering of the de Minimis Threshold of Corporate Entities Obligated to Report Emissions[22] (KT refers to kilotons of CO2e, TJ to terajoules of energy)



2. ***Begin with the end in mind, invest upfront in reporting systems and carry on learning.*** The Australian government committed to upfront investments of time and money to set up the required ICT systems for NGERS and OSCAR and allow for efficient data collection. The DIICCSRTE is responsible for annual review of the NGERS's effectiveness and regulatory burden. This has given the government the regular opportunity to act on lessons learnt to refine policy.

3. ***Empower your reporters.*** In the first years of implementing the NGER Act, the CER invested a significant amount of time in stakeholder engagement, with a particular focus on educating reporting entities. The aim was to create "empowered reporters" who are able to efficiently and correctly comply with reporting requirements. This was based on the belief that reporters who understand what they are reporting and how to report are in a better position to provide accurate and complete data, and the value Australia places on corporate citizenship. However, GHG data

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[22] Adapted from NGERS information site here: https://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/steps-for-reporting-corporations/NGER-reporting-step-1/Pages/default.aspx

reporting is still relatively new to organizations and not initially straightforward. This has meant that even with significant efforts in stakeholder engagement by the government, companies will always need some level of help when starting to report their GHG emissions.

4. ***Create a 'One-stop-shop'.*** The establishment of the Clean Energy Regulator streamlines existing and new functions into a single independent regulator. One of the main advantages is to support streamlined reporting processes which can reduce duplication of similar reporting requirements and reduce the burden on industry. Reports are compiled and submitted in electronic form through a dedicated online reporting system, the Emissions and Energy Reporting System (EERS) which delivers consistency in the data fields reported and with the NGER Regulations. This makes reporting simpler and time efficient, with less scope for redundancy and overlap in GHG data management systems.

Annex IV: Germany Case Study

As with the UK, Germany has a well-established national inventory and is obligated under the EU ETS Directive. The inventory ultimately has to comply with the UNFCCC requirements and is therefore relatively similar to the UK system, although it does use the federal states as an intermediate data collection body which the UK does not. In 2004, Germany considered setting up an integrated system to serve its needs, but the system planned was costly and would not have been ready in time for the start of the EU ETS. As a result, a less ambitious web based system was established more quickly, specifically for the EU ETS. More recently, functionality has been improved to allow verifier access pages and improve security, and the system runs more smoothly as a result.

Challenges

Germany's experience of GHG data management raised a number of challenges, these are set out below.

1. The inventory and EU ETS registry are managed separately and cannot be compared to improve the credibility of the data. The systems are designed in the way to protect the confidentiality of EU ETS participant data.

2. Software for the inventory is designed and managed by a single small company, and is closed source. This reduces the governments bargaining power in contracting improvements and may hamper innovation and improvements to the system.

3. Transport and waste sectors are compiled and submitted separately and emailed in by Comma Separated Value files. These files need to be integrated with the data provided in a different format from national statistics.

Lessons learned

Germany's experience suggests the following learning:

1. ***Combine systems for GHGs and air pollution*.** One efficient system which combines GHG and air pollutant data makes national statistics readily comparable and compliance with European directives relatively straightforward.

2. ***Invest time upfront in training users*.** Data management processes run more smoothly if time is invested up front in training reporters and central agencies, as seen in the Australia case study.

3. ***Share your best practice.*** MESAP was sold to Luxembourg and Switzerland, who had similar requirements to Germany.

4. ***Build in uncertainty analysis*.** Additional functionality which undertakes sensitivity analysis has been proven to improve the quality of the data, and further checks of the data quality are being added every year.

Annex V: Barriers Encountered by PMR Implementing Country Participants

During the writing of this report, emergent findings were discussed with participants at the PMR Technical Workshop on March 13, 2013 in Washington DC, US, and with those working on GHG data management in Chile, Ukraine, Mexico and Brazil (a list of interviewees is included in Annex G). These discussions revealed a number of barriers faced by PMR implementing countries when designing and implementing their own GHG data management systems. These barriers are summarized below.

Multiple Mandates
The mandate to collect data from industry and power generation (for example, fuel consumption and local air emissions) may not exist, or may exist within multiple ministries. Where a mandate already exists elsewhere, countries will need to decide whether it should move to a single line ministry or, if not, to agree common data requirements between line ministries to meet all regulatory purposes. Where no mandate to collect GHG data, it is likely that various systems will be used to calculate GHG emissions using national statistics and other activity data.

Capacity Constraints
Where governments have hired consultancies to manage inventories, this has sometimes led to little or no internal capacity building within ministries to collect data and to manage data management systems. Capacity building is increasingly included as part of a consultancy service offering and should be requested where consultancy support is used.

Lack of evidence for decision making
Overarching policy commitments relating to GHGs may be made by governments. However, government decision makers must choose which policies best meet these commitments, and how best to implement them (such as whether to pursue a "independent" or "integrated" approach to GHG data management). These decision makers require evidence about the relative costs and benefits of different approaches to policy or its implementation. It can be difficult to obtain this data – or even to determine what data are required – when countries are at the early stages of climate policy development. This is particularly the case where evidence collection exercises are costly and decision makers are yet to be convinced of the case for investment in scoping studies and other initial work.

Incomplete information
GHG data may be incomplete or inaccurate where data collection processes are not yet established. Governments should recognize that progress will be incremental, and consider prioritizing GHG reporting obligations on sectors based on materiality to national emissions levels. Realistic targets for data quality, that meet the demands of different policy drivers, should be identified. Two examples of established requirements for data reliability are given below.

- Year on year improvements in national statistics for industrial activity are necessary to meet the requirements of IPCC guidelines.
- Tradable credits (for example through Clean Development Mechanism projects or NAMAs) need to be based in reliable MRV requirements, developed through engagement with the corporate or government owners of GHG producing facilities.

Short term versus long term decision making

There may be pressure to make short term decisions, arising from national commitments or externally from donors. These pressures may arise at different stages, such as:

- Setting up a data management system,
- Increasing the frequency of inventory reporting,
- Implementing an ETS, and
- Implementing NAMAs.

Early identification of domestic policy priorities and the data requirements that result can help make decisions in the short term that do not compromise longer term objectives.

Understanding how to implement an ICT system
Countries understand what they would ultimately like to achieve, but not how to do it in the best way. This is important to procuring an appropriate ICT system which is in budget. This paper goes some way to clarifying these issues, but time upfront to research existing systems and clearly specify requirements are still essential.

Annex VI: Glossary

AGEIS	Australian Greenhouse Gas Emissions Information System	ICT	Information & Communication Technology
ANREU	Australian National Registry of Emissions Units	IPCC	Intergovernmental Panel on Climate Change
CCL	Climate Change Levy	KT	kilotons
CER	Clean Energy Regulator	MRV	monitoring reporting, and verification
CFI	Carbon Farming Initiative	MtC	metric tons of Carbon
CITL	Community Independent Transaction Log	NAMA	of carbon
CPM	Carbon Pricing Mechanism	NGERS	National Greenhouse and Energy Reporting Scheme
CRC	Carbon Reduction Commitment Energy Efficiency Scheme	OSCAR	Online System for Comprehensive Reporting
DCCEE	Department for Climate Change and Energy Efficiency	PMR	Partnership for Market Readiness
DCCSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education	PwC	PricewaterhouseCoopers LLP
DUKES	Digest of UK Energy Statistics	RO	Renewable Obligation
EEA	European Environment Agency	ROC	Renewable Obligation Certificate
e-GGRT	electronic greenhouse gas reporting tool	TJ	terajoules
E-PRTR	European Pollutant Release and Transfer Register	U.S. EPA	United States - Environmental Protection Agency
ETERP	Emissions Trading Electronic Reporting Project	UK	United Kingdom
ETS	Emissions Trading Scheme	UNFCCC	United Nations Framework Convention on Climate Change
ETSWAP	Emissions Trading Scheme Workflow Automation Project	US	United States of America
EU	European Union	WB	World Bank
EU ETS	EU Emissions Trading Scheme	XBRL	eXtensible Business Reporting Language
FLIGHT	Facility Level Information on Greenhouse gases Tool	XETL	eXtensible Emissions Trading Language
GHG	greenhouse gas	XML	Extensible Markup Language
GHGRP	Greenhouse Gas Reporting Program		

Annex VII: Acknowledgments

Country	Organisation	Interviewee
Australia	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education	
Australia	Clean Energy Regulator	
Brazil	Ministry of Environment	Daniel Couto Silva
Chile	Ministry of Environment	Alexa Kleysteuber Labarca
Chile	Ministry of Environment	Andrea Rudnick
Chile	Ministry of Environment	Cristobal de la Maza
Chile	Ministry of Environment	Isabel Rojas
Germany	UBA - German Environment Agency	Kevin Hausmann
Germany	UBA - German Environment Agency	Oliver Schwalb
Germany	BMU Bund	Angelika Smuda
Mexico	Ministry of the Environment and Natural Resources	Luis Munozcano
UK	Environment Agency	Steph Littler
UK	Department of Energy & Climate Change	Briony Coulson
UK	Ricardo-AEA	Ioannis Tsagatakis
UK	Aether	Justin Goodwin
Ukraine	State Environmental Investment Agency	Natalie Kushko
Ukraine	Joint Implementation Ukraine	NVP Parasiuk
Ukraine	State Environmental Investment Agency	Mykhailo Koval
Ukraine	State Environmental Investment Agency	Olga Yukhymchuk
US	US Environmental Protection Agency	Kong Chiu
US	California Air Resources Board	Webster Tasat
US	California Air Resources Board	Richard Bode
US	California Air Resources Board	Chuck Shulock

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