1 *Introduction: key notions and trade-offs involved in MRVing emissions*

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1.1 Purpose and audience for this book

This book focuses on the monitoring, reporting and verification (MRV) of greenhouse gas emissions as it is practiced in the climate economy, that is in operational carbon pricing mechanisms as well as in the quantification of operational and territorial emissions for management purposes. It provides a description of the MRV procedures in place in the fifteen most important policy frameworks – national greenhouse gas inventories supervised by the United Nations, the European Emissions Trading System, the Australian carbon tax, the Clean Development Mechanism supervised by the United Nations, etc. – and compares them along key criteria such as scope, cost, uncertainty and flexibility. As such, this book does not consider other types of MRV than that of greenhouse gas emissions, such as the MRV of climate finance or the monitoring of the efficiency of climate policies, although they also have their place in climate economics.

This book leans heavily towards the practical problems and solutions employed by those involved in the MRV of existing frameworks. In other words, it describes how MRV is currently practiced by economic agents much more than how greenhouse gas emissions could or should be monitored, reported and verified based on the most recent developments in climate sciences or the deepest rooted economics theory. As such, this book does not consider the MRV of future frameworks for which there is no set of identifiable rules and practices such as the elusive and multiform Nationally Appropriate Mitigation Actions (NAMAs) for which plans are being communicated by various countries to the United Nations.

The audience for this book are those who wish to understand the key stakes attached to monitoring, reporting and verifying emissions, and the choices made by up-and-running carbon pricing initiatives

regarding these stakes. This book is written by engineers and economists active in this field, but for a general audience who may not be proficient in climate economics or MRV procedures. This audience includes:

- businesses involved in carbon pricing and willing to grasp what underpins the intangible commodity they buy or sell;
- regulators of existing or upcoming carbon pricing and management mechanisms who seek to benchmark their regulation against similar programs;
- technology and service providers looking to assess the added value they can bring to existing practices in terms of cost-effectiveness;
- academics, in particular those working on the transaction costs associated with monitoring.

1.2 Climate economics at work

Carbon pricing mechanisms are incentives for a set of economic stakeholders to reduce their greenhouse gas emissions. The incentive is often a hard economic one (e.g., a carbon tax), but it can take softer forms, such as reputational incentives attached to meeting an emissions reduction pledge for a country, local government or a company, or branding incentives derived from environmental labeling (e.g., carbon footprint of products). The first explicit economic incentive to reduce greenhouse gas emissions was created by a bilateral contract between two private actors – an electricity producer and a forest owner – in 1989 (Bellassen and Leguet, 2009). However, carbon pricing mechanisms only started to bloom in the 1990s. This occurred first in the form of carbon taxes in a few countries such as Sweden and Denmark, and then, in the early 2000s, as cap-and-trade system and offset mechanisms which create a supply and a demand for greenhouse gas emissions reductions among nations and businesses.

In 2013, implemented and scheduled emissions trading schemes and carbon taxes put an explicit carbon price on at least 7 percent of the world's emissions (World Bank, 2013). They are being implemented in all countries of the European Union, in some American States and Canadian Provinces and in Asia (Japan, South Korea, some Chinese provinces). The largest listed companies made their carbon footprint part of their reputation through the Carbon Disclosure Project (2,132

reporting companies in 2011). The same goes for industrialized countries through the United Nations Framework Convention on Climate Change (UNFCCC) and, to a lesser extent, to local governments and economic actors through national reporting requirements. In a nutshell, carbon is now an important asset for many public and private stakeholders. It is nevertheless quite a peculiar asset, as it is intangible, invisible and odorless. These characteristics make the MRV of greenhouse gas emissions all the more crucial, as the only concrete link between the physical world and these large but intangible markets and mandates.

Climate economics are currently undergoing far-reaching changes. The European Union Emissions Trading System and the Clean Development Mechanism, which together made up 99 percent of carbon markets in 2011 value, are imperiled: as of June 2013, carbon allowances in the European Emissions Trading Scheme plummeted by 70 percent to around €5/tCO_2e in two years' time while carbon credits issued by the Clean Development Mechanism are not worth more than 50 euro cents (Bellassen et al., 2012; World Bank, 2013). This stupendous fall raises questions on the very relevance and effectiveness of cap-and-trade mechanisms and has revived discussion of alternative solutions such as carbon taxes in Europe. At the same time, new local cap-and-trade schemes are being enacted in other parts of the world such as the US and China.

International agreements on climate change do not look healthier than European carbon markets. The clout of the Kyoto Protocol is also fading: it will at most cap 14 percent of global emissions between 2013 and 2020 (Morel et al., 2013) following the withdrawal of Canada, Russia and Japan. Yet, its successor due by the end of 2015 is far from having disentangled the thorny question of effort sharing between signatory parties.

MRV procedures stand through this storm as one of the few solid pillars of climate action. Indeed, the need for MRV is a common feature of all the possible future carbon pricing mechanisms, be they carbon taxes, cap-and-trade systems, environmental labeling or carbon footprint disclosure. Moreover, while national governments have historically been reluctant to commit to emissions caps in an international agreement, they all stand to gain in common methods and procedures to quantify emissions occurring elsewhere – whether internationally or subnationally. This is probably why MRV is one of the fastest-moving topics in international climate negotiations, and one of

the most likely to succeed (Dupont et al., 2013). This is why we believe that a reference book on MRV in climate economics is timely and that its relevance will not be decreased as the details of upcoming carbon pricing mechanisms unfold.

1.3 Scale, scope, uncertainty and related trade-offs: key definitions and stakes of MRV in climate economics

Before MRV gets its entry in all English dictionaries with its corresponding grammar, MRVed, MRVing, etc., it is worth distinguishing what exactly is covered by each of the three terms.

- **Monitoring** covers the *scientific* part of the process. It involves getting a number for each variable part of the equation which results in the emissions estimate. This ranges from direct measurement of gas concentration using gas meters to the recording of proxies such as fuel consumption based on the bills of a given entity. The use of proxies is common practice, through the general equation:

  Activity data × **Emission factor** = Greenhouse gas emissions

  where activity data is the proxy (e.g., fuel consumption, heads of cattle) and emission factor is the conversion factor (e.g., tons of CO_2 per liter of burnt fuel, tons of CO_2e per animal per year). Both activity data and emission factor change over time and hence need to be monitored. Activity data nevertheless tends to vary more frequently than emission factors.
- **Reporting** covers the *administrative* part of the process. It involves aggregating and recording the numbers, explaining how you came up with them in the requested format, and communicating the results to the relevant authority, such as the regulator or the top management of the company.
- **Verification** covers the *police* part of the process. It is usually conducted by a party not involved in monitoring and reporting who checks that these two steps were conducted in compliance with the relevant guidelines. Its purpose is to detect errors, be they innocent mistakes or frauds.

Although not plentiful, the existing literature on MRV in climate economics agrees on three possible scales which greatly influence how

MRV can be conducted: territory, entity and project (Cochran, 2010; IGES, 2012; Ninomiya, 2012).

- The **territorial scale** includes all emissions occurring within a given geographic area such as a country or an administrative region. All activities and entities operating within the area are considered. Examples include national greenhouse gas inventories supervised by the United Nations, regions or cities which have committed to a voluntary or statutory cap on emissions, and jurisdictions engaged in programs for Reducing Emissions from Deforestation, forest Degradation and other changes in forest carbon stocks (REDD+). Although the last example is restricted to forest-related emissions, it still includes all those occurring within the jurisdiction, no matter the activity or entity responsible for them.
- The **entity scale** includes emissions related to the operations of a given public or private entity. In a few cases, all the emissions of the entity are included, such as businesses participating in the Carbon Disclosure Project or entities subject to the "Grenelle 2" French environmental law enacted in 2010. Most often, however, only part of the emissions corresponding to a restricted set of operations is included. This is the case of mechanisms putting an explicit price on carbon such as the European Union Emissions Trading System, the Australian carbon tax or the Californian Emissions Trading Scheme. In those cases, the MRV occurs at the scale of individual facilities.
- The **project scale** includes emissions stemming from specific emissions reduction projects. These projects are often focused on a given activity, such as destroying an industrial gas or spreading efficient cookstoves. The number of entities and the geographic area considered is then adapted *ad hoc* to the considered activity. The main example is offset projects, be they certified by the dominant Clean Development Mechanism of the United Nations, or by other standards such as the Verified Carbon Standard or the Gold Standard. As opposed to the two other scales, the MRV of greenhouse gas emissions always comes together with the MRV of greenhouse gas emissions reduction at the project scale: both the project emissions and its counter-factual – or baseline – emissions are monitored, reported and verified at the same time, and along the same rules.

No matter the scale, the first question that comes to mind when quantifying greenhouse gas emissions is: which type of emissions shall be taken into account? Answering this question means choosing the gas – CO_2, CH_4, N_2O, etc., the activities – combustion, manufacturing processes, agricultural practice, the size threshold and more technically, the **scope**. The scope broadly defines how far the responsibility of a territory, entity or project extends in terms of emissions. The three scopes defined by the World Resource Institute and the World Business Council on Sustainable Development's *Greenhouse Gas Protocol* (WRI/WBCSD, 2004) are currently the reference in this regard.

- **Scope 1** includes only the direct emissions from a project, entity or territory. For a restaurant offering delivery services, Scope 1 emissions would likely be limited to fuel consumption during the delivery.
- **Scope 2** includes the direct and indirect emissions produced elsewhere linked to electricity, steam, heating and cooling used by the project, entity or territory in question. For our restaurant, this would include its electricity and heat consumption, even if both are likely produced elsewhere by a separate entity.
- **Scope 3** corresponds to direct, indirect and up-stream and embodied emissions of goods and services either consumed in the project, by an entity or within a territory (carbon footprint approach). For our restaurant, Scope 3 would include many activities such as the emissions embedded in the food it processes, in the journey of its employees and customers, in the manufacturing of the motorcycle used for delivery, etc.

A similar concept closely linked to the idea of responsibility for emissions and commonly encountered is the gradient from *production-based approach* to *consumption-based approach*. Scope 1 corresponds to an entirely *production-based approach* while Scope 3 corresponds to a pure *consumption-based approach*.

The last concept which is mobilized throughout the book is the **uncertainty** associated with the MRV of emissions. This concept involves a flurry of terms which are not always understood in the same manner. In this book, we adopt the terminology of the Intergovernmental Panel on Climate Change (IPCC): uncertainty corresponds to the difference between the estimate and the actual value. Hence, it covers all potential sources of error. Two types of errors are commonly distinguished

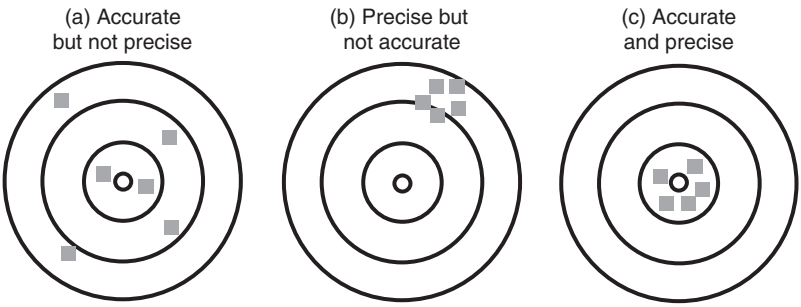

Figure 1.1 Uncertainty: accuracy and precision
Assuming the objective is to sample the bulls eye in the center of the target: (a) the average of all sampling points would be close to the center and so would have low bias, but the points are widely spaced and therefore have low precision; (b) all points are closely grouped indicating precision but they are far from the center and so are biased and inaccurate; (c) all points are close to the center and closely grouped, so they are precise and accurate. The uncertainty is then minimal.
Source: Adapted from IPCC (2006).

(Figure 1.1): systematic errors or bias which decrease the **accuracy** of the estimate (e.g., miscalibrated gas meter, unit error in the reporting) and random errors which decrease the **precision** of the estimate (e.g., sampling error, errors of copy in the reporting). In monitoring, lack of precision and accuracy can both lead to uncertain estimates but only the first can be dealt with by increasing the number of samples. Bias can only be reduced by monitoring and reporting the same source of emissions with a change in the method. In reporting, both types of errors can be reduced through quality control and verification.

Scale, scope and uncertainty lead to the two necessary trade-offs in the MRV of greenhouse gas emissions, as explained by Cochran (2010): cost vs. uncertainty and information relevance vs. comparability. The trade-off between **cost and uncertainty** is one of the key threads of this book. For each carbon pricing mechanism considered, this book identifies whether flexibility provisions are in place to adapt uncertainty requirements to the cost incurred by stakeholders. These provisions may take the form of ***de minimis* thresholds**, that is, threshold levels of emissions under which monitoring and reporting are not required, or **materiality thresholds**, that is, threshold levels of errors under which errors are tolerated during verification. They can also

take a more continuous form, for example by increasing the cost of compliance or discounting the benefits from carbon credits in proportion to the uncertainty of monitoring.

The second trade-off between **information relevance and comparability** comes from the difference in information needs from case to case. A country with only a few trees such as Monaco will see the quantification of emissions from its forestry sector as a complete waste of resources when it comes to designing climate mitigation policies. But Canada or Brazil may not see it that way. However, letting each country choose the sources it monitors, the method it uses to report them and the format under which all this is reported would greatly hamper the comparison of emission levels between countries. The same goes for cities, companies and offset projects depending on their specific context and needs. As this book focuses on carbon pricing and reporting mechanisms for which dominant guidelines exist, in most cases issued by a regulator who has the ability to enforce them, this second trade-off is somewhat less relevant. It nevertheless comes up here and there (e.g., Chapter 3 on subnational inventories and Chapter 9 on company-level carbon footprint).

In a nutshell, five cross-cutting questions are asked in each chapter on the schemes being presented:

- What are the MRV requirements?
- What are the costs for entities to meet these requirements?
- Is a flexible trade-off between requirements and costs allowed?
- Is requirements stringency adapted to the amount of emissions at stake (materiality)?
- What is the balance between comparability and information relevance?

1.4 Outline, editorial choices and comparison tools between chapters

This book contains the description and analysis of fifteen of the MRV approaches practiced in carbon pricing and management mechanisms of various forms: cap-and-trade, tax, offsets, environmental labeling, etc. In choosing these mechanisms, we gave the priority to compliance schemes, that is schemes designed by a regulator who issues clear and mandatory guidelines and who has some means of enforcing the guidelines. These schemes are more relevant than voluntary

schemes for two reasons: first, they are far more important in terms of amount of emissions concerned or in terms of amount of money at stake when they exist. Second, the practice of MRV in compliance schemes is necessarily unique as it follows a unique set of guidelines published by the regulator. In other words, it is not up to each entity to choose how it proceeds in terms of MRVing its emissions. This allows us to state what are the existing MRV requirements rather than describe how some entities proceed in terms of MRV within a flurry of different approaches. This explains why there is no chapter on the carbon footprint of products, for example. Although it has voluntarily been monitored and reported in some cases, it is not yet widely practiced. There is no mandatory or consensual set of guidelines, and hence, no verification by a third party that guidelines have been correctly implemented. No ex-post analysis is therefore possible in such a case.

To allow the comparison between the different systems treated in distinct chapters written by different authors, an *MRV ID Table* compiles the answers to 41 MRV-related questions in each chapter. These tables provide a clear and concise basis for comparison to readers. They were also instrumental in compiling the general lessons drawn in Chapter 15 on the uncertainty requirements of the different systems, the costs incurred by stakeholders and the provisions that help in striking a good balance between cost and uncertainty in monitoring, in reporting and in verification. A glossary for each of the 41 items of this MRV ID Table is provided in the appendix to this chapter.

This book contains three main parts. Each one is dedicated to one of the three scales of MRV described earlier: territory, entity and project. Each part begins with a chapter on the system we identified as the *trendsetter* for this scale. Criteria for qualifying as a *trendsetter* include number of entities concerned, amount of emissions concerned, longevity of the scheme, amount of money at stake, etc. The other chapters of the part consist of a shorter description and analysis of other examples of MRV – or *variants* – at the same scale. To select these *variants*, we used the same criteria as for the *trendsetter*, but we also valued their originality compared to the *trendsetter*.

Part I addresses MRV at territorial scale. National GHG inventories supervised by the United Nations set the trend in this category: they have been compiled on a yearly basis since 2003 by about 40 parties to the United Nations Framework Convention on Climate Change

(UNFCCC). Almost all these countries have strong incentives to comply: countries whose inventories are assessed as inadequate during the verification by international experts may be disconnected from the flexibility mechanisms for the Kyoto Protocol. Being disconnected often entails millions of euros of losses for businesses within this country in addition to the reputational losses for the country itself. Chapter 2 addresses this *trendsetter* in detail. Two smaller *variants* are discussed for comparison: Chapter 3 discusses the MRV of emissions conducted by subnational governments – whether cities or regions – over their territorial jurisdiction. While the regulatory incentives and guidelines are still in their infancy and are often non-binding at this scale, three similar sets of guidelines can be considered as forming the norm: the Global Protocol for Community-Scale Greenhouse Gas Emissions at the international level, the European Commission's Covenant of Mayors at the EU level and the Bilan Carbone Territorial at the French national level. The second *variant* addressed in Chapter 4 addresses the MRV of forest emissions at jurisdictional scale. Although still in its infancy as well, REDD+ has touted several jurisdictions to implement an MRV framework for their forests in order to benefit from existing and upcoming incentives tied to the reduction of forest emissions at jurisdictional level. The guidelines published by the Verified Carbon Standard – the dominant standard for voluntary offsetting – provide MRV requirements which are starting to set the norm in this field. They are compared to the more recent UNFCCC MRV guidelines for REDD+, agreed upon at COP19 in November 2013.

Part II addresses MRV at the entity scale. The European Union Emissions Trading System (EU ETS) caps the emissions of 11,000 industrial sites and generates exchanges worth between €50 and €80 billion per year (Kossoy and Guigon, 2012). In operation since 2005, it was the first large-scale cap-and-trade system to be set up for greenhouse gas emissions. Failing to comply with the scheme is fined at the heavy rate of €100 per tCO_2e. At the entity scale, it therefore sets the trends for other burgeoning carbon pricing mechanisms worldwide. Chapter 5 addresses this *trendsetter* in detail. Five smaller *variants* are presented for comparison: Chapter 6 describes the Australian carbon tax. Very similar to the EU ETS as it is also based on Scope 1 emissions from industrial sites, this carbon pricing mechanism covers the waste sector which is not subject to the EU ETS. The Californian emissions trading scheme which started in 2013 brings an additional MRV