Insights on Monitoring, Reporting, and Verification in Carbon Pricing

Developing effective and inclusive MRV systems

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Insights on Monitoring, Reporting, and Verification in Carbon Pricing: Developing effective and inclusive MRV systems

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Executive Summary

Robust monitoring, reporting, and verification (MRV) is the foundation on which every carbon pricing instrument rests. A price applied to inaccurate or unverified emissions data cannot deliver the abatement it is designed to produce. This report sets out how MRV works across common forms of carbon pricing and what governments designing a domestic compliance market should take into account from international experience. It draws on desk research into primary policy and regulations and academic literature, complemented by expert interviews. This includes four case studies covering Quebec, Alberta, China, and the European Union. The case studies explore how each jurisdiction implements the steps of MRV, alongside their various challenges and approaches to non-compliance and distributional concerns. Findings from the desk research and case studies provide recommendations on how policy-makers can design an effective and inclusive MRV system.

Main Findings

- **A reliable MRV system rests on sound institutional foundations established in law**. Primary legislation defines covered entities, measurement and reporting obligations, verification standards, and penalties for non-compliance. These institutional arrangements ensure that the data entering the national emissions registry is accurate and supports the credibility of the country's carbon pricing system.
- **Coordination across international carbon pricing systems is increasingly important**. With developments such as the European Union Carbon Border Adjustment Mechanism (EU CBAM) and Article 6 of the Paris Agreement, alignment on MRV standards is crucial. Where established international quantification methods exist, jurisdictions should align with them where possible.
- **Tiered requirements for different categories of emitters can mitigate the distributional impacts of MRV systems**. Several approaches can address MRV compliance costs that may fall disproportionately on smaller emitters. These include high emissions thresholds that exclude smaller emitters, tiered methodologies and default emission factors, lighter requirements for minor sources that contribute very little to a facility's total, and sector-specific exceptions.
- **The MRV systems reviewed have not yet put gender equality and social inclusion and just transition principles into practice in their governance arrangements**. As a result, there is little documented evidence that MRV design itself included inclusive governance mechanisms, such as meaningful stakeholder engagement or tripartite social dialogue. The benefits of MRV are also unevenly accessible, with smaller, less-resourced entities less able to convert compliance into competitive advantage.
- **Participatory MRV approaches can strengthen community ownership, improve data quality, and build technical capacity**. Extending equity and inclusion to the growing MRV workforce can also help ensure that a more diverse range of workers acquires these increasingly valuable skills. More broadly, the just transition lens can operate not only at the level of workers and communities but

also among states, ensuring that all countries have a voice in shaping international MRV standards.

- **A sequenced approach to MRV lowers the risk of misallocation of allowances, builds regulator and entity capacity, and provides evidence for cap and threshold setting**. Any new compliance market has to decide whether to start with mandatory greenhouse gas reporting and set up a carbon price later or launch the pricing system at the same time.
- **Jurisdictions differ in how much verification they conduct in-house versus delegate to accredited third parties**. Some jurisdictions take a risk-based approach to decide which emitters' reports to verify internally. Others choose to verify the data of all covered emitters.
- **A reported tonne should mean the same thing across emitters and over time, which requires the same methodologies be applied across the system**. Harmonized rules under the EU's Monitoring and Reporting Regulation keep allowances comparable across member states; admitting offsets into a compliance market requires the offset tonne to meet a comparable standard; and cross-border linking of emissions trading systems (ETSs) depends on similar MRV protocols.
- **MRV systems can build on existing institutional infrastructure such as installation-permitting regimes and energy-tax administrations**. Reusing these existing structures streamlines the process of developing an MRV system, as operators have access to shared data flows that can inform scoping decisions from the start. The same logic extends to verification, where existing accreditation systems can be reused.
- **Transparency at every stage of the MRV process is the principal safeguard against data integrity failures and a foundation of system credibility**. It makes reported emissions data easier to verify and accessible to the public, and clearly published rules make compliance simpler for covered entities.
- **MRV systems must be designed for change**. The methodologies, emissions factors, and reporting requirements they rely on evolve over time. Consequently, MRV programs should be built to allow regular updates because they improve continually through experience, trial and error, and changing environmental circumstances.
- **MRV is widely framed as a compliance tool and cost, but can also generate market access, reputational, and revenue benefits**. Strong compliance can make a firm more competitive, build a firm's reputation for sound emissions management, and generate revenue from selling surplus allowances to others. Framed well, MRV can be understood as institutional infrastructure that provides firms the opportunity to benefit from the carbon pricing system.

Recommendations

To put credible, internationally recognized MRV institutions in place, governments can

- build the institutional capacity to design, implement, and enforce MRV obligations, retaining in-house capacity to recheck reported data;
- ensure a sufficient pool of competent verifiers, accredited domestically where possible;
- extend institutional design consultations beyond regulated industry to include labour and community representatives from the outset; and
- model domestic MRV standards on existing global standards to increase coordination potential with other ETSs.

To design an MRV system proportionate to emitters and tailored to jurisdictional context, governments can

- incorporate tiered MRV requirements based on the size and capacity of the emitter to minimize disproportionate burdens on smaller facilities;
- begin with mandatory greenhouse gas reporting and only attach a price once 2 to 3 years of MRV data are in hand, applying the same staged approach each time the system extends to a new sector;
- apply the same quantification methodologies across all covered entities, so reported tonnes stay comparable, aligning with established international methods where they exist and addressing measurement uncertainty and non-continuous data in a reasonable, defensible way; and
- build MRV on existing infrastructure, such as environmental taxation and accreditation bodies, mapping adjacent legal regimes early so scope and reporting deadlines align with the current infrastructure.

To ensure MRV systems are transparent and adaptable, governments can

- publish all installation-level data on a consistent basis unless there is a clear case for confidentiality, in a form compatible with existing carbon pricing mechanisms, such as the EU CBAM, to facilitate easier coordination;
- place regulations in administrative decisions instead of legal statutes in areas of the MRV system that will continue to evolve, so that elements with the steepest learning curve—quantification methodologies in particular—can be revised as techniques advance and industry and stakeholder feedback comes in; and
- communicate MRV benefits alongside compliance obligations.

To advance equity, inclusion, and just transition through MRV design, governments can

- embed gender equality and social inclusion and just transition considerations into MRV methodologies, collecting and reporting disaggregated data so distributional outcomes can be measured and assessed over time; and
- build community capacity before market entry.

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Abbreviations and Acronyms

CBAM	carbon border adjustment mechanism
CCER	China Certified Emission Reduction
CEMS	continuous emissions monitoring systems
dMRVA	digital monitoring, reporting, and verification
ETS	emissions trading system
EU	European Union
GESI	gender equality and social inclusion
GHG	greenhouse gas
ICAP	International Carbon Action Partnership
ICAT	Initiative for Climate Action Transparency
ICVCM	Integrity Council for the Voluntary Carbon Market
ISO	International Organization for Standardization
MEE	Ministry of Ecology and Environment
MRV	monitoring, reporting, and verification
PMR	Partnership for Market Readiness
PMRV	participatory MRV
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDGs	Sustainable Development Goals
tCO_2e	tonnes of carbon dioxide equivalent
TIER	Technology Innovation and Emissions Reduction
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCI	Western Climate Initiative

1.0 Introduction

1.1. The Role of MRV in Carbon Pricing

Carbon pricing has become one of the most widely deployed instruments in climate change mitigation policy. As of early 2025, 80 direct carbon pricing instruments were in operation worldwide, generating over USD 100 billion in 2024 revenues and covering roughly 28% of global greenhouse gas (GHG) emissions (World Bank, 2025). Their environmental and economic integrity, however, depends on the quality of the data that underpins them. Monitoring, reporting, and verification (MRV) is the empirical foundation on which compliance obligations, allowance[1] allocations, tax liabilities, and credit issuances rest.

Effective carbon pricing cannot work without solid MRV. The reasons are both technical and institutional. Technically, MRV tracks the conversion of physical activity into the tonnes of carbon dioxide equivalent (tCO_2e) that the pricing instrument acts on. Without consistent measurement methods and comparable reporting boundaries, prices applied across entities or jurisdictions lose their meaning (International Carbon Action Partnership [ICAP], 2021). Institutionally, MRV is the mechanism through which a carbon pricing system establishes trust—among regulated entities that obligations are applied fairly, among market participants that allowances and credits represent real reductions, and among the public that the policy is delivering its stated objectives (Singh et al., 2015). Weak MRV undermines all three forms of trust, and with them the political durability of the pricing instrument itself.

Moreover, there is growing recognition, articulated in key international climate agreements and policy frameworks, that climate mitigation instruments—including carbon pricing—should contribute to equitable development, protect vulnerable groups, support a fair distribution of benefits and burdens, and facilitate a just transition to decarbonization. For this to hold, the scope of MRV systems would need to extend beyond GHG accounting to include sustainable development and gender and social inclusion (GESI) indicators. In practice, however, these commitments remain only partially operationalized within MRV systems. An analysis of a large series of voluntary carbon market offset projects found that mandatory disclosure of gender impacts remains the exception rather than the rule (Nicholson & Besco, 2025) and much of the United Nations Framework Convention on Climate Change's (UNFCCC's) own gender language remains aspirational rather than binding (Guerrero & Kovács, 2025). The result is a persistent gap between normative commitment and operational practice. MRV system design has both the potential and the responsibility to help close it.

Therefore, this report explores how jurisdictions have approached the design of MRV systems and what transferable lessons governments can draw on to build domestic compliance markets that are both technically robust and socially just. To answer this, the report develops a conceptual framework for MRV in carbon pricing, draws on case studies of mature and

[1] An allowance is a tradable permit, issued by the regulator up to the level of the cap, that authorizes the holder to emit 1 tCO_2e. Regulated entities must surrender allowances equal to their verified emissions each compliance period.

emerging jurisdictions, and synthesizes findings and recommendations for governments designing domestic compliance markets.

1.2 Methodology

This report adopts a qualitative comparative approach, combining desk research with semi-structured expert interviews.

Case Study Selection

The case studies capture variation along three dimensions: (i) instrument type, including cap-and-trade and intensity-based systems; (ii) maturity, from long-established systems to pilots and recently operationalized national mechanisms; and (iii) regional and institutional context, with cases drawn from North America, Europe, and Asia. The jurisdictions are the linked California–Quebec cap-and-trade system and Alberta's Technology Innovation and Emissions Reduction (TIER) regulation in North America; the European Union (EU) Emissions Trading System (ETS) in Europe; and the China ETS. Together they illustrate a range of approaches to measurement prescriptiveness, the allocation of verification responsibilities, and the integration of offsets into compliance frameworks.

Desk Research

The desk research draws on three categories of sources. First, primary regulatory and legal documents—statutes, regulations, and technical guidance issued by each jurisdiction's competent authority. Second, comparative and analytical material from international institutions. Third, literature addressing the design, performance, and administrative cost of MRV systems.

Expert Interviews

Semi-structured interviews with practitioners and stakeholders span three categories. The first is government regulators and MRV practitioners who design or operate compliance MRV systems. The second is intermediaries and aggregators, such as project developers, non-governmental organizations, and cooperatives. The third is civil society and research organizations able to identify potential gaps and broader participation issues. Interviews follow a common protocol adapted to the role of each interlocutor.

Scope and Limitations

This report covers MRV for carbon pricing instruments and their regulated entities; broader national GHG inventory MRV under the UNFCCC Enhanced Transparency Framework is discussed only where it relates to pricing-related MRV. The case studies illustrate design options rather than represent all operating systems. MRV administrative costs are discussed qualitatively; fuller quantification would require primary data collection beyond this study's scope. Similarly, evidence on integrating equity and inclusion considerations into MRV systems remains limited, reflecting this emerging practice. Finally, the analysis reflects regulations and practice at the time of writing, in a field evolving rapidly, particularly around digital MRV (dMRV) and the operationalization of Article 6 of the Paris Agreement.

2.0 MRV in Carbon Pricing Systems: Conceptual framework

This chapter sets out the conceptual framework that underpins the case studies and the practical considerations developed later in the report.

2.1 Definitions

GHG-related MRV in Carbon Pricing

MRV is the process by which emissions of GHGs (or, for crediting mechanisms, emission reductions and removals) are quantified, documented, and independently checked. In carbon pricing, MRV refers more narrowly to the system that quantifies and confirms the emissions (or reductions) of entities subject to the pricing instrument. Its three components can be summarized as follows (Singh et al., 2016).

Measurement (or monitoring) is the quantification of emissions, typically by the regulated entity itself, using either direct measurement (e.g., continuous emissions monitoring systems [CEMS]) or calculation-based approaches that multiply activity data with emission factors and other parameters. CEM carries equipment and maintenance costs, while calculation-based approaches are cheaper but are only as reliable as the factors and inputs they draw on. Most systems therefore reserve CEMS for the largest or most variable sources and use calculation elsewhere.

Reporting is the disclosure of monitored data to the competent authority in a standardized format and on a defined timetable, usually annually, with documentation of the methodologies, data sources, and assumptions used.

Verification is the independent check that reported information is accurate, complete, consistent, and free from material misstatement. In other words, a neutral and independent "referee" that gives the system credibility (N. Lee, personal communication, 2026). It is typically conducted by accredited third-party verifiers under recognized international standards such as International Organization for Standardization (ISO) 14064-3:2019 and ISO 14065 (ISO, 2019, 2020), though the precise model varies by jurisdiction. Verifiers provide outcomes to the overseeing department, which then uses the verified data for compliance assessment and allowance allocation.

Two settings determine how much weight a verification carries. The first is the level of assurance. Compliance systems such as the EU ETS require reasonable assurance, where the verifier carries out detailed testing on data and quality and control measures to state that the report is free from material error, while voluntary markets often accept the lighter limited assurance, where the verifier only reports that nothing came to its attention and carries out less (European Commission 2021; Partnership for Market Readiness [PMR] & ICAP, 2021). The second is materiality— the threshold of significance used to judge whether errors, omissions, or misstatements, individually or aggregated, would misrepresent the data and influence the decisions of the intended users.. Together, these produce data fit for compliance

decisions while the registry records and reconciles allowance holdings against verified emissions, preventing double counting (European Commission, 2021; PMR & ICAP, 2021). MRV responsibility is spread across a consistent set of actors. The regulator sets the rules and enforces compliance; entities measure, report, and surrender allowances or pay tax; accredited third-party verifiers confirm the data; and, where offsets or trading are involved, project developers, verification bodies, and financial-sector participants rely on that data's integrity.

Non-GHG MRV: UN Sustainable Development Goal (SDG) and GESI indicators

MRV systems have expanded to include non-GHG indicators, which provide complementary measures that capture development and equity outcomes associated with carbon pricing. Two categories are particularly relevant.

Sustainable development (SDG-type) indicators capture the environmental, economic, and social co-benefits of carbon pricing, ranging from improvements in local air quality and biodiversity outcomes to job creation and access to clean energy. The inclusion of such indicators is now a formal requirement under the Article 6.4 mechanism of the Paris Agreement, which obliges activities to deliver and report sustainable development contributions in addition to GHG mitigation (UNFCCC, 2021). In the voluntary carbon market, the Integrity Council for the Voluntary Carbon Market's Core Carbon Principles (ICVCM, 2024) similarly require disclosure of sustainable development impacts as a condition for high-integrity status, and standards such as the Gold Standard and Verra's Climate, Community & Biodiversity Standards have built explicit SDG monitoring into their methodologies (Gold Standard, 2019; Verified Carbon Standard Association, 2017).

GESI indicators capture the equity and inclusion dimensions of carbon pricing by examining distributional and participation outcomes. They assess how benefits, costs, risks, and opportunities are distributed across different groups, who participates in decision-making processes, and whether affected groups (including women, Indigenous People, workers, and vulnerable communities) can meaningfully engage in carbon pricing activities. Examples include the share of women or Indigenous community members benefiting from a project, access to employment or capacity-building opportunities, and the design features that lower participation barriers for smaller and lesser-resourced actors. GESI indicators have gained prominence in international frameworks, with the UNFCCC's enhanced Lima Work Programme on Gender and its gender action plan (UNFCCC, 2019) shaping expectations across both compliance and voluntary instruments, and with the ICVCM's Core Carbon Principles requiring safeguards for Indigenous Peoples' rights and benefit-sharing (ICVCM, 2024).

The expansion of MRV to cover non-GHG indicators reflects a broader shift in the rationale of carbon markets and pricing instruments. Increasingly, these instruments are expected not only to deliver least-cost mitigation but also to support sustainable development objectives, advance equity considerations, and contribute to just transitions by ensuring that the benefits and burdens of decarbonization are more fairly distributed (ICAP, 2026).

Box 1. dMRV: An emerging practice

dMRV refers to MRV systems that draw on digital technologies to streamline the collection, processing, and verification of emissions and mitigation data (World Bank, 2022). It can reduce reliance on manual measurement and in-person verification, lower transaction costs, and enable near-real-time tracking of mitigation outcomes.

Applications include satellite-based monitoring of forest carbon stocks, sensor-based monitoring of clean cooking and energy access projects, and registry interoperability through digital infrastructure. The World Bank identifies three primary benefits. These are greater cost-effectiveness, particularly for small-scale and dispersed activities; improved data accuracy and transparency; and increased market confidence in the integrity of issued units (World Bank, 2022). At the same time, dMRV raises new questions about data privacy, technology costs, and capacity needs in developing countries.

For the purposes of this report, dMRV is treated as an emerging dimension of MRV system design rather than a separate category.

2.2 Approaches to MRV Depending on Type of Carbon Pricing

This section explores MRV in each of the principal carbon pricing instrument types.

MRV in Compliance Emissions Trading Systems

Each year, regulated companies must surrender one allowance to the regulator for every tonne of verified emissions or for every tonne of verified emissions above a baseline emissions threshold. In cap-and-trade systems, the obligation follows from a fixed cap on total emissions, so monitoring and reporting cover emissions alone. In intensity-based systems, the obligation is expressed per unit of output, so emitters must monitor and report production data alongside their emissions. These allowances are also traded as financial assets, and compliance and trading of allowances only work if the underlying emissions data is accurate (PMR & ICAP, 2021). Compliance ETSs therefore impose monitoring requirements on regulated installations, prescribe reporting templates and timelines, and mandate verification by accredited third parties before surrender obligations are calculated.

MRV Design Across the ETS Life Cycle

MRV requirements typically evolve as an ETS matures, and earlier design choices shape what is feasible later. Three broad phases can be distinguished (PMR & ICAP, 2021; World Bank, 2025).

Mandatory GHG Reporting as a First Step

A mandatory GHG reporting program is typically the first step in building MRV capacity. It establishes baseline emissions data, identifies covered entities and sectors, builds the regulator's institutional capacity, and tests data collection systems. Some jurisdictions maintain such a program as a standalone instrument; in those that introduce an ETS, it

provides the foundation for credible caps and benchmarks and ensures that, at launch, both regulators and entities have practical experience with measurement and reporting (Singh et al., 2015).

Pilot Phase

Many jurisdictions launch ETSs in a pilot phase characterized by simplified MRV requirements, lower verification stringency, and limited or no financial consequences for compliance failures (ICAP, 2026; World Bank, 2025). For example, California made third-party verification optional during the program's first year (PMR & ICAP, 2021). This lets entities and regulators learn the system in a low-stakes environment, identifying data gaps and methodological weaknesses before they become consequential. Pilot phases typically last between 2 and 5 years.

Full Operation

In a fully operational ETS, MRV requirements typically converge on a recognizable set. These include detailed monitoring plans approved ex ante by the competent authority, prescribed or tiered measurement methodologies, standardized digital reporting, annual third-party verification by accredited bodies, and penalties for non-compliance. The transition from pilot to full operation is often phased, with verification stringency, sectoral coverage, and the cost of non-compliance tightening over time (PMR & ICAP, 2021). Stringency is calibrated not only to the size of the emitter but to the type of emission. Combustion CO_2 is comparatively straightforward to quantify, following directly from fuel use and well-established emission factors. Process emissions—for example from cement or aluminum production—along with fugitive methane and nitrous oxide are harder to measure and harder to verify. A system extending coverage beyond power and combustion must therefore match its measurement and verification requirements to the emission type (Intergovernmental Panel on Climate Change [IPCC], 2006, 2019). Setting workable deadlines requires coordination with adjacent legal regimes. Sometimes an emissions monitoring report depends on data used elsewhere, most commonly an energy-tax declaration. In that case, the MRV deadline should not fall before that declaration is due, and ideally lands at the same time or shortly after (R. Geres, personal communication, 2026).

MRV and Carbon Taxes

While the majority of this study is focused on carbon markets, MRV is also a topic relevant to carbon taxation. Carbon taxes apply a price per tonne of CO_2-equivalent emissions and therefore, in principle, rely on the same emissions data as an ETS to calculate the tax base. The standard typology distinguishes three approaches—upstream, downstream, and hybrid—each with very different MRV implications (Organisation for Economic Co-operation and Development, 2023; United Nations Development Programme [UNDP], 2025; World Bank, 2017).

Upstream carbon taxes are levied on the carbon content of fuels at the point of import, production, or distribution. Because the carbon content of standard fuels is well established, the tax can be administered through existing fuel-tax infrastructure. Tax authorities apply published emission factors to volumes already reported for excise purposes, with no need for installation-level emissions monitoring. Verification is correspondingly lighter than for

downstream designs. British Columbia, the Nordic countries, Mexico, Argentina, Colombia, and Uruguay follow this design (UNDP, 2025; World Bank, 2017).

Downstream carbon taxes are applied directly to emissions at the point of release—power plants, refineries, large industrial facilities. This design requires an installation-level MRV system closer to that of an ETS. Facilities must measure or calculate their emissions using prescribed methodologies, report them on a defined cycle (typically annually), and in most cases have those reports verified by an accredited third party before the tax is assessed. Chile and Singapore are the clearest examples. Chile's system covers around 40% of national emissions and relies on collaboration between the tax authority and the environmental regulator, with the latter setting monitoring criteria and overseeing technical verification (Dumoulin, 2021). To keep costs down, both jurisdictions built their reporting systems on pre-existing institutional frameworks and placed the measurement and reporting burden on the regulated entities themselves (UNDP, 2025). Even so, implementation costs for downstream systems tend to be higher than for upstream designs (UNDP, 2025).

Hybrid designs combine the two. South Africa's carbon tax is the leading example. It taxes large emitters directly at the installation level under the National Greenhouse Gas Emission Reporting Regulations, while allowing emitters to use offsets to reduce part of their tax liability up to a prescribed limit (World Bank, 2017). They require both a downstream-style installation MRV system and infrastructure to track and cancel offset credits but give policy-makers more flexibility on coverage and compliance costs.

MRV in Offset Crediting and Voluntary Carbon Markets

Offset crediting mechanisms—including carbon-removal projects and the voluntary carbon market (VCM)—do not measure absolute emissions. Instead, they measure the difference between actual emissions or removals and a counterfactual baseline (Singh et al., 2016). Their MRV works at the project level rather than the facility level. It depends on additionality (the activity would not have happened without credit revenue), a credible baseline, and careful handling of leakage and reversal (Lebling et al., 2024). Verification runs in two steps. Accredited third-party bodies first validate the project design, then confirm that the claimed reductions or removals occurred. Registries serialize the credits to prevent double counting (ISO, 2019; ICVCM, 2024). For carbon removal, MRV gives near-term transparency over removal claims. In time, it also provides the basis for counting novel carbon dioxide removal toward national inventories and nationally determined contributions (Lebling et al., 2024).

In the voluntary carbon market, the same logic applies, but standard setting and oversight are largely private, and each program sets its own methodologies, accredits its own verifiers, and runs its own registry (Gold Standard, 2025; World Bank, 2025). Permanence is a particular concern for nature-based projects, such as forestry and soil carbon.

The four instrument types described above are not mutually exclusive. Many jurisdictions combine them—for example, an ETS with a limited offset mechanism or a carbon tax that recognizes offset credits to reduce the tax liability (ICAP, 2026; World Bank, 2025). What matters for MRV design is that each instrument places distinct demands on the data infrastructure, and that the system is fit for the specific compliance decision it must support.

3.0 GESI and Just Transition in MRV Systems

How an MRV system is designed and implemented can shape who participates in carbon pricing mechanisms, whose contributions are recognized, and how the costs and benefits of climate action are distributed. This section explores the GESI implications of MRV through two interconnected dimensions: (a) participation and accessibility and (b) the distribution of costs, benefits, and risks.

Participation and Accessibility

The participation and accessibility questions differ between compliance and voluntary markets. In compliance markets, participation is largely a matter of regulation. Entities are mandated to engage with the MRV system once they cross the relevant emissions thresholds, and the covered population skews toward large industrial emitters with the capacity to meet monitoring and verification requirements. At the global scale, however, differences in country-level participation in shaping MRV standards have been observed. Some governments help shape international accreditation standards (e.g., the ISO standards), while others are far less involved, leaving the latter (and vulnerable groups within them) more exposed to requirements they had no hand in shaping (N. Lee, personal communication, 2026). This is a just transition concern that mirrors participatory MRV at the level of states.

MRV design matters most in voluntary markets. No one is required to take part, so the demands an MRV system places on participants decide who can join. Participants meeting MRV obligations require technical expertise, access to digital tools and reliable data collection systems, and the financial resources to fund reporting and pay for third-party verification. MRV therefore acts as a gate to the voluntary market.

The actors most likely to be excluded are smaller, resource-constrained ones (e.g., community-based organizations, smallholder producers, and local initiatives) for whom technical and financial requirements weigh disproportionately (Cacho & Lipper, 2006). The barriers also appear to be gendered. Women-led carbon-credit projects are underrepresented because of unequal access to finance, technical knowledge, and carbon markets (Phillips et al., 2022). Although direct evidence on the GESI dimensions of MRV remains limited (Nicholson & Besco, 2025), the broader literature suggests MRV requirements can reinforce existing inequalities unless inclusion is explicitly addressed.

Several standards acknowledge gender equality, Indigenous rights, and safeguards such as free, prior, and informed consent. Even so, explicit MRV requirements remain limited. Gold Standard is one of the clearest examples. It requires projects to carry out a gender analysis, collect sex-disaggregated data, set gender indicators and targets, and monitor gender equality outcomes across the project life cycle. Its higher certification tiers reinforce this, rewarding projects that demonstrate positive impacts on gender equality. In contrast, most carbon standards mention gender only as a safeguard. They give little guidance on how these outcomes should be monitored and verified (Phillips et al., 2022; Guerrero & Kovács, 2025).

From a just transition perspective, how MRV systems are designed and governed matters as much as the indicators they measure. The International Labour Organization stresses that just transition processes need tripartite social dialogue. Governments, employers, and workers should be meaningfully engaged at every stage, from policy design through implementation and evaluation (International Labour Organization, 2015; Molina, 2022). Without their meaningful participation, especially by workers, MRV systems may fall short of just transition principles. This can happen even when the systems include social and gender-related indicators. Newer initiatives, such as Nigeria's Just & Gender-Inclusive Transition MRV Framework, illustrate how more intentionally designed, participatory MRV systems can integrate gender, inclusion and just transition considerations from the outset (Initiative for Climate Action Transparency, 2023, 2024), offering a useful reference point for the next generation of MRV systems.

Box 2. Participatory MRV in practice

Participatory MRV (PMRV) is another emerging practice, which involves Indigenous Peoples and local communities directly in monitoring, reporting, and verification. Beyond improving data quality, it can strengthen community ownership, recognize local knowledge, and foster stakeholder cooperation (Boissiere et al., 2014).

Field experience from an Indigenous community-owned REDD+[2] project in Southeast Asia illustrates PMRV in practice. Through a long-standing partnership with a technical organization, community members were trained to conduct tree measurements, such as tree diameter measurements and plot-based sampling. For more than 6 months, the community members then conducted forest carbon inventories across 60 sample plots, using the internationally recognized REDD+ methodology. The resulting inventory formed the basis of the project's Project Design Document, demonstrating that community-generated data can meet recognized carbon standards with sustained technical and capacity building. The experience also shows that meaningful participation requires long-term investments in trust and capacity development, rather than one-off technical interventions. (Civil society actor, personal communication, 2026).

Inclusion in the carbon market is not only a question of who participates in it, but also of who works within it. Running an MRV system depends on a skilled workforce, such as the verifiers, auditors, and technicians who measure, check, and sign off on emissions data. These are, in effect, green jobs. Green employment, however, is unevenly distributed. Women remain a minority in the sector (Alexander et al., 2024). Persons with disabilities are routinely left out of climate workforce policy altogether (International Labour Organization & Fundación ONCE, 2023). Equal participation therefore also means making sure the green jobs emerging alongside MRV are accessible to all and consistent with just transition principles.

[2] Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD+) is a UN framework that rewards developing countries for reducing emissions from deforestation and forest degradation.

Distribution of Costs, Risks, and Benefits

The costs, benefits, and risks of MRV are not distributed equally across actors. The sections below trace each dimension in turn.

Costs Associated With MRV

The costs of MRV are real, concrete, and unevenly borne—yet modest in aggregate. For governments designing a compliance market, the useful question is not whether MRV is expensive but how its costs are driven, distributed, and contained by the design choices made at the outset.

MRV costs arise even when the allowance price or tax rate is low or zero. Running the MRV system itself imposes costs on governments and compliance entities. Compliance entities still pay for monitoring equipment and its calibration, data collection, staff time, and third-party verification. Regulators bear the cost of building and staffing reporting systems, registries, and oversight functions (PMR & ICAP, 2021). Moreover, the size of the MRV cost burden depends on the carbon pricing instrument. Upstream taxes that build on existing fuel-tax administration are cheap to run. Downstream designs and ETSs that require facility-level measurement and third-party verification cost more. More prescriptive, higher-tier methodologies raise accuracy at the expense of cost (PMR & ICAP, 2021; UNDP, 2025; World Bank, 2017). The aggregate cost, however, is not the whole story. Smaller firms and smaller emitters face markedly higher MRV costs per tonne than large emitters (Vanderheyden et al., 2026). The reason is that much of the MRV cost is fixed rather than proportional to emissions.

In voluntary crediting and carbon-removal markets, MRV cost becomes a matter of access. For several carbon dioxide removal methods, per-tonne MRV costs can be two to three times the carbon price itself in major compliance markets (Mercer et al., 2024). Project-based crediting shows the same concentration of cost. For an Indigenous community-owned carbon market project in Southeast Asia, validation and verification by an accredited body can cost approximately USD 80,000 per project (Civil society actor, personal communication, 2026). This figure covers only the verification fee. It excludes travel costs, which can be substantial when local verification bodies are unavailable and external verifiers must be brought in. Project monitoring also requires significant investments in equipment, such as distance-measuring devices for forest inventories. For projects with extensive monitoring needs, these costs multiply and further increase overall MRV expenses.

Risks

MRV can be framed as a risk-management device. Its purpose is to protect a carbon pricing mechanism against the risk that the reductions or removals it pays for are not real, guarding against mismeasurement and misreporting.

In compliance markets, the transferred risk is bounded and largely procedural. The most direct is the penalty regime for non-compliance (administrative fines, suspension of allowances, excess of emissions penalties or in some systems criminal sanctions for misreporting). These penalties can be substantial. Under China's ETS, for example, fines range from five to ten times the illegal gains from non-compliance (see the China case study). Alongside this sits the administrative burden of the system itself. That burden includes meeting reporting deadlines,

responding to verifier queries, closing data gaps, and managing the reputational consequences of restatements. These risks are generally manageable for larger emitters but can press harder on smaller covered entities with thinner compliance teams.

In voluntary markets, MRV requirements may also generate uneven risk profiles across different market participants (Cacho & Lipper, 2006). Compliance challenges may result in delayed issuance of carbon credits, additional verification costs, reduced revenues, or exclusion from carbon market participation, particularly where MRV complexity increases transaction costs or affects the benefits ultimately received by participants (Vanderheyden et al., 2026). These risks are particularly significant where participation in carbon markets is linked to livelihoods, community development initiatives, or local natural resource management. For smaller, resource-constrained actors, such disruptions may be harder to absorb, affecting both the viability of participation and the benefits derived from carbon market activities.

Benefits

Like costs and risks, the benefits of MRV are distributed unevenly, with better-resourced actors tending to reap a greater share.

At the system level, robust MRV gives a carbon pricing instrument its value. Without credible and verifiable data, allowances and credits cannot be trusted, traded, or priced, and the environmental integrity of the mechanism falls away. The most fundamental beneficiary of sound MRV is therefore the market itself and, by extension, the public trust in the real emission reductions it is meant to deliver.

At the level of individual actors, the benefits are more selective. In compliance markets, well-resourced firms are often best placed to turn MRV from a cost into an advantage. Strong compliance can support a reputation for sound emissions management and a credible reduction plan. It can also generate revenue from selling surplus allowances to less efficient operators (N. Lee, personal communication, 2026). In voluntary markets, credible MRV lets a project command buyer confidence and access climate finance. By contrast, actors who cannot meet MRV requirements have no access to this opportunity. That finance is itself unevenly available. Women and women's organizations, for instance, face particular constraints in accessing it (Phillips et al., 2022). Participatory approaches to MRV design are seen as a way to address these issues (Boissiere et al., 2014; see Box 2).

4.0 Case Studies

This chapter presents case studies of MRV systems in individual jurisdictions. Each one shows how the actors, processes, and design choices outlined above work in practice.

4.1 MRV in Quebec

Quebec runs a cap-and-trade system linked to California under the Western Climate Initiative (WCI). Launched in 2013 and connected to California in 2014, the cap-and-trade system now covers around 80% of the province's emissions. Quebec's MRV requirements are set by the Minister of the Environment and governed primarily through the regulations respecting mandatory reporting of emissions and a cap-and-trade system for GHG emission allowances (Government of Quebec, 2026b).

Measurement

Two types of emitters are required to comply with MRV regulations: industrial emitters, which are subject to an emissions threshold, and fuel distributors, which are subject to a quantity distributed threshold. Emitters measure emissions using a list of prescribed methodologies. These include CEM, mass-balance calculations, published emission factors, emissions sampling, and emissions estimation models (Government of Quebec, 2026a). Emitters subject to the cap-and-trade regulation have stringent requirements, whereas other emitters may choose how to quantify GHG emissions. The regulation sets detailed technical requirements for how measurement must occur. Quebec's quantification protocols are adopted from methodologies developed by the WCI coalition. Quebec regulations must be issued in French alongside an English translation. As a result, all WCI protocols had to be translated and aligned with Quebec drafting conventions, which required substantial adaptation (V. Leblond & O. Lacroix, personal communication, 2026).

Reporting

Emitters report their emissions to the Quebec government each year by June 1. Annual GHG reports must contain the total quantity of GHG emissions, information on any captured, stored, or transferred emissions, detailed operational and biomass data, and the calculation methods used to derive them (Government of Quebec, 2026a). This obligation predates the cap-and-trade system. Quebec already had a mandatory emissions reporting regulation, so the quantification protocols were built into that existing instrument. That approach avoided amendments to the underlying environmental legislation and sped up the rollout (V. Leblond & O. Lacroix, personal communication, 2026).

Verification

Before a report is accepted, verification is conducted independently by accredited third-party organizations (Government of Quebec, 2026a). Quebec's regulations set detailed verification requirements, including mandatory site visits at least once every 3 years. Once entities submit, the government also verifies the data in each report internally (V. Leblond & O. Lacroix, personal communication, 2026). This sequential internal verification contrasts with China's

concurrent data verification, explored in a case study below. Unlike California, which accredits its own verifiers, Quebec relies on verification bodies accredited by the Canadian accreditation body (and accepts those accredited by the equivalent U.S. body). This was a pragmatic choice. Quebec had no prior accreditation expertise, and a sufficient, if small, pool of already-accredited firms existed at launch (V. Leblond & O. Lacroix, personal communication, 2026).

Cost, Equity, and Other Modalities

Quebec's threshold design, a cost-proportionality measure, tries to soften the disproportionate MRV burden on small emitters. Monitoring and reporting obligations begin at 10,000 tCO_2e per year, but only facilities emitting 25,000 tCO_2e or more are required to join the cap-and-trade market. Fuel distributors that distribute more than 200L of fuel are also obligated to participate. Quebec's cap-and-trade system also allows limited use of carbon offsets, though they play only a minor role. Use of offsets is capped at 8% of total required reductions (ICAP, 2022). Offsets must also originate within the WCI-linked system, coming only from Quebec- or California-approved programs.

In cases of non-compliance, entities face monetary administrative sanctions. Entities who fail to register, provide false information, or fail to surrender allowances are subject to a fine of CAD 40,000 to CAD 3,000,000. Emitters who fail to cover their GHG emissions are liable to a fine of CAD 3,000 to CAD 600,000 per metric tonne. The Minister of the Environment may also suspend the allocation of allowances to the emitter (Government of Quebec, 2026b).

Challenges

The operation of Quebec's MRV system reveals some challenges. The first is that third-party verification has structural blind spots. Verifiers are instructed to verify only emissions targeted by the cap-and-trade. Biogenic CO_2 and other exclusions fall outside their scope. This leaves a significant portion of some GHG statements unverified by the third party. The government's internal review regularly finds mistakes there (V. Leblond & O. Lacroix, personal communication, 2026). Because third-party verification is limited, the government runs its own internal data validation on all of the roughly 130 emitters' GHG statements each year. Since the reporting deadline is June 1, June and July are an intense period of calculation and conformity review. The work demands deep familiarity with Quebec's industrial processes and engineering judgment that cannot be outsourced to third-party verifiers. A few errors come up most often in this validation process. Some emitters present documents to the third-party verifier instead of using the government's database. Others report in different units than the regulation requires. Some natural gas distributors also use the reference temperature of the U.S. and federal Canadian governments, which differs from Quebec's (V. Leblond & O. Lacroix, personal communication, 2026). This makes internal data validation the single biggest operational burden (V. Leblond & O. Lacroix, personal communication, 2026).

Another challenge is rigidity. Because the quantification protocols are embedded directly inside the regulation (rather than referenced as external methods, as British Columbia does), every emission-factor correction or methodological update requires a formal regulatory amendment (V. Leblond & O. Lacroix, personal communication, 2026). Hence, annual regulatory modification is unavoidable and labour intensive.

4.2 MRV in Alberta's Carbon Pricing System

Alberta's MRV requirements are established under the Emissions Management and Climate Resilience Act and given effect through the Technology Innovation and Emissions Reduction Regulation (TIER), administered by Alberta Environment and Protected Areas (Government of Alberta, 2019).

Measurement

Measurement is carried out by emitters under Alberta's Greenhouse Gas Quantification Methodologies documents, which provide sector-specific formulas and approved data sources (Government of Alberta, 2023b). Because TIER is intensity-based, emitters must quantify not only their absolute emissions but also their emissions per unit of output against a sectoral benchmark.

The framework applies automatically to facilities emitting 100,000 tCO_2e or more per year. Smaller facilities may apply to opt in if they emit at least 2,000 tCO_2e a year, belong to an emissions-intensive, trade-exposed sector, or compete with a regulated facility (Government of Alberta, 2019). Reporting obligations reach lower than compliance obligations. Facilities that emit 10,000 tonnes or more of CO_2e in a calendar year must report their emissions data under Alberta's Specified Gas Reporting Program. This compliance threshold is considerably higher than in the other jurisdictions examined, where mandatory participation begins closer to 25,000 tCO_2e in Quebec and 26,000 tCO_2e in China.

Reporting

Regulated facilities must report both their production and their GHG emissions annually (Government of Alberta, 2023a). Reporting also covers imported electricity, heat, and hydrogen (Government official, Alberta, personal communication, 2026). These reports must follow the quantification methodologies issued by the Government of Alberta and cover total emissions, activity data such as fuel use and production volumes, and the methodologies applied. The production data forms the basis of intensity benchmark calculations (Government of Alberta, 2025).

Verification

Submitted reports must be verified by an accredited third-party GHG verifier (Government of Alberta, 2025), whose requirements are set out in the province's Standard for Validation, Verification and Audit guidance documents (Government of Alberta, n.d.). Verification applies only to facilities above 100,000 tCO_2e or those that have opted in (Government of Alberta, 2023b) and each year, Alberta also selects a small, risk-based sample of emitters to have their reports re-verified by contracted verifiers. This re-verification has helped address errors missed in the first round (Government official, Alberta, personal communication, 2026).

Cost, Equity, and Other Modalities

Alberta's threshold approach also serves an equity purpose. Because most of the province's emissions come from large entities, the high compliance threshold means few small businesses

must take part, leaving smaller emitters largely shielded from the mandatory MRV burden (Government official, Alberta, personal communication, 2026).

Alberta maintains a significant offset system within TIER, using approved protocols to calculate emission reductions from eligible activities. From 2026 onward, facilities can use offset credits to meet up to 90% of their compliance obligation (ICAP, 2026). This is exceptionally high in comparative terms. California caps offset use at 6% for 2026–2045; Quebec sits in a similar single-digit range; China's pilot ETSs cap offsets at 5%–10%, and the EU ETS has admitted no offsets since Phase 4 (ICAP, 2026). Offsets are valued as a way to extend the economic incentive to reduce emissions into areas the government may not want to regulate directly. Municipal waste and agriculture, for example, are more politically palatable to address through offsets than regulation (Government official, Alberta, personal communication, 2026). With up to 90% of compliance obligations meetable through offsets, Alberta's offset MRV protocols effectively determine who can access the carbon market and on what terms—making their inclusivity a central equity question in the TIER system.

For non-compliance, Alberta's robust regulatory and legislative framework lets it move up a compliance ladder as required. The more serious steps are generally reserved for cases where there is an identified intent to provide false information (Government official, Alberta, personal communication, 2026). Most non-compliance, however, involves simple mistakes, and the usual response is to require resubmission of inaccurate items. Materiality thresholds determine when resubmissions are required. Thresholds are tighter for larger facilities and slightly looser for small sites (Government official, Alberta, personal communication, 2026). Content errors are caught through compliance review of the annual and verification reports. Errors are found both against and in favour of the reporter. Late filings and payments are handled the same way. Alberta's main tool is the compliance order, which sets a clear obligation to submit overdue elements, and persistent non-compliance can be escalated to Crown Debt Collections (Government official, Alberta, personal communication, 2026).

Challenges

Offset systems, annual reports, and third-party verifications are publicly accessible, but given commercial sensitivities, the industrial side is less transparent (Government official, Alberta, personal communication, 2026). This is a gap that may have direct implications for accountability and just transition monitoring. Overall, Alberta faces an ongoing challenge in achieving consistent performance across third-party verifiers. Since moving to mandatory verifier accreditation roughly 5 years ago, the province has invested in training materials, deeper review of verifiers' processes and working papers, and more constructive feedback (Government official, Alberta, personal communication, 2026).

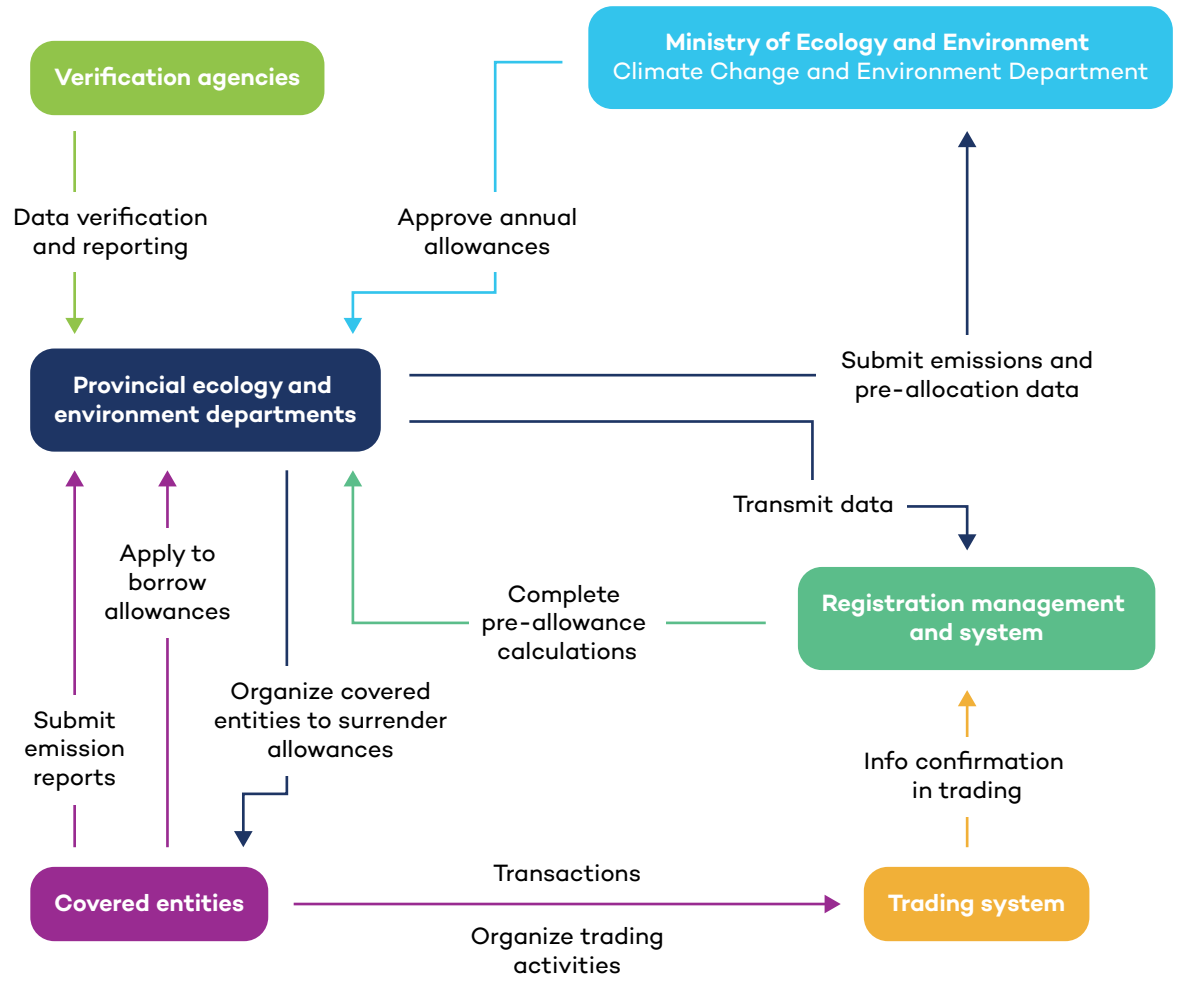
Beyond Alberta and Quebec, several challenges recur across Canada's MRV systems. Credible MRV depends on credible inputs, yet new entrants sometimes lack adequate monitoring systems (N. Lee, personal communication, 2026). By the time reports reach verification, missing or poorly captured data cannot be reconstructed, making some data errors impossible to address (N. Lee, personal communication, 2026). As demand for third-party verification grows across Canada, verifier-capacity shortages may surface (N. Lee, personal communication, 2026).

Consistency is a repeated theme. Canada's federal backstop combined with varied provincial designs, methodologies, and requirements creates inconsistencies that make compliance challenging for companies operating across provinces.

4.3 China Case Study

China launched its intensity-based national ETS in July 2021. It is administered through a multi-level framework combining central oversight with decentralized implementation (see Figure 1). The system is led by the Ministry of Ecology and Environment (MEE), which sets the overall regulatory framework and MRV requirements, defines allocation methodologies, and approves annual allowances for covered entities. The MEE empowers provincial ecology and environment departments to oversee emissions reporting and verification processes, review emissions data submitted by regulated entities in their provinces, coordinate allowance allocation, and manage compliance procedures. These provincial authorities interface between covered entities and the central government (Qian et al., 2018).

Figure 1. China's national ETS—institutional framework



Source: Authors' analysis.

Measurement and Reporting

Compliance entities in the power, cement, iron and steel, and aluminum sectors with annual emissions exceeding 26,000 tCO_2e must monitor and report their emissions (and production given it is an intensity-based system) to provincial ecology and environment departments. They must also submit data quality control plans covering each entity's emission facilities and accounting methods These plans must be approved by the provincial authorities. Monthly GHG reports must contain data on fuel consumption, carbon content of fuel, electricity and heat consumption, industrial process emissions, and more.

The monthly reports may be submitted no later than 40 calendar days after the end of each month. Annual reports may be submitted no later than March 31 for entities in the power sector and no later than June 30 for entities in the iron and steel, cement, and aluminum sectors (MEE, 2024). To streamline reporting, entities can connect their monitoring equipment directly to the national ETS platform for data processing.

For sectors that do not yet carry ETS compliance obligations—such as petrochemicals, chemicals, papermaking, and domestic aviation—entities emitting more than 26,000 tonnes CO_2e must still conduct MRV, in preparation for the ETS's eventual expansion into them. These reports are reviewed under provincial third-party verification policies, bringing these sectors closer to the standards already applied to ETS entities.

Verification

China's national verification regulations are governed by the 2022 Technical Guidelines for the Verification of Enterprise Greenhouse Gas Emissions for Power Generation Facilities, and the 2024 Interim Regulations on Carbon Emissions Trading Management (hereafter the Interim Regulations), which set out requirements for verification agencies and their role in MRV procedures. These requirements draw to some extent on international verification standards. Chinese verification agencies are, however, not yet accredited by an accreditation body.

In early February 2026, the MEE issued a notice setting out the reporting and verification requirements for the next phase of the ETS. Verification agencies appointed by provincial authorities must verify the 2025 data and submit the verified reports to the MEE by December 31, 2026.

Since the launch of the ETS, China has also run a second, government-commissioned layer of verification of the reported data. This second check is not performed by officials internally; it is carried out by verification agencies that are selected and paid for by the provincial authorities. Past data fraud cases in which consultants colluded with emitters to submit falsified data confirmed the necessity of the parallel verification process (Development Partner Representative, personal communication, 2026). Up to 3 or 5 years ago, a verification body would submit a report, and the government would conduct a second round to check its quality. The system has since shifted to a model under which operators submit their data monthly to a government system, while third-party verification is carried out annually. Third-party verification and internal data validation now run in parallel (Development partner representative, personal communication, 2026).

Cost, Equity, and Other Modalities

China applies the usual threshold approach, excluding the smallest emitters and covering only entities that emit at least 26,000 tCO_2e per year. China's MRV cost structure differs from the other jurisdictions examined. The main concerns are distributional, between levels of government and across regions. Because the government runs its own verification in parallel, much of the ETS cost burden falls on it, at both the ministry and sub-national level (Development partner representative, personal communication, 2026). Provincial disparities also shape how equitably MRV is implemented across China. More developed provinces generally have greater institutional capacity, a larger pool of qualified verification bodies, and more experience managing emissions data. Less-developed provinces, by contrast, may face gaps in staffing, technical expertise, data quality management, and oversight.

For enforcement, violations fall into two broad categories. The first covers violations related to emissions reporting and verification. The second covers other forms of non-compliance. These are regulated by the 2024 Interim Regulations, which significantly strengthened the ETS's compliance and enforcement framework by introducing more comprehensive regulatory and penalty provisions.

The regulations cover emitters, supervisory authorities, third-party verifiers, and technical service providers. For violations related to emissions reporting and verification, they adopt an income-based penalty approach. The approach differs from the EU ETS. There, different penalties can be distinguished: a penalty of 100 euros for each allowance that is not surrendered to cover verified reported emissions by the required deadline, and administrative penalties imposed when other infringements occur. In China's ETS, financial penalties are based instead on the illegal gains the violating entity obtained. Fines may range from five to ten times the amount of illegal income. Where illegal income is below a prescribed threshold or cannot be determined, minimum statutory penalties apply. Beyond financial penalties, entities must take corrective action within a set time frame. Failure to rectify violations may reduce future allowance allocations. In serious cases, verification agencies may lose their qualifications, which bars them from carrying out verification within the ETS.

Regulated entities are allowed to use domestic offset credits issued under the China Certified Emission Reduction (CCER) scheme to cover up to 5% of their compliance obligations.

MRV foundational rules for offset credits are laid out in the following regulations:

- Management Rules for Registration of Voluntary Greenhouse Gas Emission Reductions (Trial);
- Guidelines for the Design and Implementation of Voluntary Greenhouse Gas Reduction Projects (National Carbon Market Information Network, 2023);
- Voluntary Greenhouse Gas Emission Reduction Trading and Settlement Rules (Trial). (National Carbon Market Information Network, 2023)

In late 2023, the State Administration for Market Regulation released further implementation rules detailing the accreditation and oversight of third-party validation and verification bodies.

Challenges

China's MRV system has faced data negligence and falsification by firms and verifiers. In 2022, the MEE publicized four cases of false emissions reporting by third-party verifiers. One firm, Zhongtan Nengtou Tech Co, had advised companies to submit false coal samples and forged test reports, while SinoCarbon Innovation & Investment Co. and Qingdao Xinuo Renewable Co. ignored obvious problems in emissions reports, overlooking fraudulent tests and treating on-site verification as a formality ("China Slams," 2022).

In response, China introduced data quality control plans and higher penalties and strengthened its three-tier review mechanism, under which emissions reports are checked at the municipal, provincial, and national levels (MEE, 2025). The government treats data quality and fraud seriously that China's national ETS and CCER can be considered stricter than some other carbon markets this respect.

The reformed CCER has gone particularly far on transparency, publishing all project information and comments online, with reviewers applying genuine professional expertise. National ETS data, while not public, are transparent across levels of government. Together, these measures have made data fraud markedly harder for operators and consultants alike (Development partner representative, personal communication, 2026). However, most data errors are not deliberate in the sense that operators often do not know how to calculate or report the data, producing abnormal figures in the system. As operators grow familiar with the system, abnormal data diminishes, and the government's burden to address errors falls (Development partner representative, personal communication, 2026). This learning curve, however, is not uniform. Operators in less-developed provinces and newer sectors face steeper capacity gaps and may need targeted support as the ETS expands.

4.4 EU ETS Case Study

Launched in 2005, the EU ETS is the world's first and largest compliance emissions trading system. It operates as a cap-and-trade scheme across the 27 EU member states plus Iceland, Liechtenstein, and Norway. Whereas Quebec and Alberta cover facilities based on annual emissions (tCO_2e), the EU ETS uses the size of a facility's combustion units for combustion installations. Most stationary installations are captured once their combustion units in the case of combustion activities exceed a combined rated thermal input of 20 MW (European Commission, 2018a). In other sector activities such as production, melting capacity or no thresholds apply. More than one sector activity can be carried out by an installation. Specific rules are defined in law on what falls within the scope of the EU ETS.

Unlike systems that phase MRV in gradually, the EU introduced MRV and the carbon price together in 2005. There was therefore no prior reporting pilot to build a facility-level baseline (R. Geres, personal communication, 2026). This caused some initial difficulties. Germany, for example, overestimated covered emissions by roughly 20 million tCO_2e and made allocation decisions that proved wrong later on.

The EU has since shifted its approach. MRV is now established in new sectors first before compliance obligations attach. For example, municipal waste incineration installations are

already reporting their emissions, while decisions on ETS coverage of these installations for 2026–2027 remain pending. Aviation and maritime were brought into MRV before being folded into the cap, with maritime reporting from 2018 and compliance from 2024. This phased approach gives regulators a baseline data set and gives operators time to build capacity before the obligations take effect (R. Geres, personal communication, 2026).

The EU ETS MRV system differs structurally from single-jurisdiction systems because the relevant law sits at two levels. The first is EU legislation—the ETS framework directive together with a dedicated MRV implementing legislation covering monitoring, reporting, verification, and accreditation. The second is national implementation by member states (R. Geres, personal communication, 2026). Early ETS rules in the years 2005–2012 left significant room for member state interpretation of the EU legislation. Harmonization then tightened over successive periods when two monitoring, reporting, verification, and accreditation regulations were established in 2013: one on monitoring and reporting and the other one on verification and accreditation of third-party verifiers. These regulations had a direct effect on obligated entities (installations), verifiers, regulators, and other parties. This was driven largely by member states that complained looser enforcement elsewhere created a competitive disadvantage (R. Geres, personal communication, 2026). Today, the EU-level rulebook is highly harmonized, set out in the EU ETS Directive (2003/87/EC) and the implementing regulations below. Member states remain responsible for administering and enforcing it. The compliance-cycle rules are the Monitoring and Reporting Regulation (European Commission, 2025)and the Accreditation and Verification Regulation (European Commission, 2025).

These regulations clearly delineate the key roles. The Commission sets the cap and the common rulebook; member state competent authorities administer and enforce it; operators measure and report; and accredited third-party verifiers, accredited and supervised by national accreditation bodies, confirm the data.

The EU ETS is a mature system whose monitoring and verification requirements are well-developed and serve as a model for carbon pricing systems in China and elsewhere (Development partner representative, personal communication, 2026). R. Geres (personal communication, 2026) goes further, calling the resulting data set "one of the best information bases we can imagine"; in his view, historical inter–member state implementation differences have been largely resolved through successive tightening of the rulebook.

The process of the EU's MRV cycle is laid out below.

Measurement

Before each monitoring period, the operator must obtain approval for their monitoring plan from its member state's competent authority, then measure emissions against that plan under the Monitoring and Reporting Regulation (MRR) (Art. 11-12) and the MRR using calculation or measurement-based approaches (European Commission, 2018a). Accuracy is structured through a tiered methodology, based on installation size, emission source, and source stream significance. Larger installations and higher-impact source streams must use higher (more accurate) tiers, while smaller installations and lower-impact streams may use simpler methods (European Commission, 2025, Art. 19). In practice, higher tiers require site-

specific sampling and analysis of fuel carbon content, emission factors and other parameters, and lower measurement uncertainties, while lower tiers permit default emission factors (e.g., IPCC defaults) and standard commercial-grade metering (European Commission, 2018a). Stringent requirements apply the quality assurance and control measures an operator must implement to mitigate risks to errors in the data (for example, calibration of measurement equipment).

Reporting

The operator submits a verified annual emissions report to the competent authority by March 31 of the following year. Reports are increasingly shared through standardized and digital templates. The operator surrenders one allowance for every tonne of verified CO_2-equivalent emitted (European Commission, 2018a). Operators that fail to surrender enough allowances face a penalty of EUR 100 per tonne not covered by surrendered allowances and still must surrender the missing allowances. EU countries have also established additional administrative penalties in their national law for specific infringements of EU ETS law.

Verification

Before submission, the report is verified by an accredited third-party verifier in conjunction with ISO/IEC 17029 and ISO 14065 and the Accreditation and Verification Regulation to confirm the report is free from material misstatement and the monitoring plan has been correctly implemented. Verifiers are accredited and supervised by national accreditation bodies and must comply with the Accreditation and Verification Regulation (European Commission, 2018b; ISO, 2020). National authorities also oversee the verifiers themselves annually The system draws on pre-existing accreditation infrastructure rather than building a bespoke verifier body. The accreditation bodies themselves are also required to comply with the Accreditation and Verification Regulation and ISO 17011, and are regularly monitored and supervised in peer evaluations organized by the European Cooperation for Accreditation.

Independent third-party verification has proved reliable. This is partly because the technical expertise required typically sits outside government, which can make authority-led verification less effective (R. Geres, personal communication, 2026). Jurisdictions adopting this model therefore need to check whether they have a domestic verifier base and lean on existing accreditation structures where they exist. Verifier availability was a real constraint at launch but is no longer the core issue. The current pressure is the growing volume of items needing verification (R. Geres, personal communication, 2026). Site visits are generally mandatory and only under certain specific conditions can be waived for simple cases where data can be accessed remotely, and in the case of low-emitting installations and simple monitoring situations (if this is justified by the verifier's risk analysis) (European Commission, 2018a). The EU MRV system depends heavily on manual verification. Verifiers perform the calculations and submit reports to the competent authorities. Once those competent authorities receive the verified emissions reports, these regulators generally carry out checks on the verified emissions reports. China, by contrast, wants to reduce human intervention. It uses automatic smart meters that transmit consumption data directly to the national platform, which is why it is keenly interested in CEMS (Development partner representative, personal

communication, 2026). In the EU, the emissions reports of installations using CEMS have to be verified as well, as meters can malfunction or leave data gaps.

Cost, Equity, and Other Modalities

The EU framework offers a developed cost-proportionality scheme. Member states can exclude small installations emitting under 25,000 tCO_2e per year from compliance and MRV obligations as long as equivalent emission reduction measures are in place, and simplified monitoring and reporting requirements have been implemented to monitor whether those installations exceed the threshold of 25,000 tCO_2e per year. Since 2021, ultra-small emitters under 2,500 tCO_2e can be exempt entirely, without equivalent emissions reduction measures. Where member states adopt the exclusion, these facilities report using simpler methodologies to monitor and report emissions, as well as to monitor whether the threshold is exceeded.

Underlying these exclusions and simplifications is a broader principle of proportionate monitoring, backed by an "unreasonable costs" safeguard that caps required monitoring improvements (European Commission, 2018a). If an installation cannot meet the highest tier because of unreasonable costs or technical infeasibility, they can apply lower tiers under certain specific conditions. The term unreasonable costs and technical infeasibility is defined in legislation. Smaller installations may use lower measurement tiers and standardized values rather than site-specific sampling, accepting some reduced accuracy as part of the cost-burden calibration (European Commission, 2018a; R. Geres, personal communication, 2026). Together, these mechanisms are the most systematic attempt among the studied jurisdictions to embed cost-proportionality into MRV design as a principle, though they address cost and equity within the compliance framework only.

The EU ETS in its current Phase 4 form does not permit international offset credits for compliance. Credits were allowed in earlier phases but have been excluded since 2021. Article 6 of the Paris Agreement may reopen questions about international units but leaves installation-level MRV unchanged (R. Geres, personal communication, 2026).

Challenges

The EU ETS shows that a highly prescriptive, third-party-verified MRV system can operate at scale across many jurisdictions while maintaining integrity. Between 2005 and 2024, emissions from stationary installations in the EU fell roughly 51%. One of its significant achievements is the harmonization of MRV and accreditation across 30 countries. This makes allowances comparable and tradable across borders. Although the EU ETS has a well-established MRV system, inconsistencies in reports occasionally arise (R. Geres, personal communication, 2026).

Sectors left outside the main cap can still be brought in through a dedicated second system. ETS2 does this by calculating emissions "upstream," placing the obligation on fuel suppliers. Rather than monitoring each building or vehicle where fuel is burned ("downstream"), ETS2 calculates emissions from the quantity of fuel released for consumption in sectors covered by ETS2. This covers the same emissions while monitoring a few hundred suppliers instead of millions of end users. Monitoring began in 2025, with full operation planned for 2027.

Verified emissions at installation level, along with the list of installations that have not surrendered sufficient allowances, are published annually in the registry. The more detailed underlying data, however, becomes available only about 3 years after reporting. Making that detail accessible sooner would let audiences such as academic researchers and journalists check the data (M. Pahle, personal communication, 2026). The lag also limits the ability of communities and civil society to monitor whether the system's burdens and benefits are equitably distributed.

Beyond its domestic role, the EU MRV regime is increasingly a de facto international reference point. The EU CBAM requires non-EU jurisdictions and installation operators exporting carbon-intensive goods (such as steel, aluminum, cement, and fertilizers) to adhere to EU methodologies for MRV, including those pertaining to accuracy, independent verification, reliability, and public transparency of installation-level data—and verifiers active in EU compliance must themselves be EU-accredited. Turkey, a neighbour with high EU export exposure, has already implemented an MRV system substantially derived from the EU ETS (R. Geres, personal communication, 2026).

5.0 Considerations for Government: A practical framework for domestic compliance market MRV

5.1 Discussion of Key Findings

Drawing the threads of the preceding chapters together, a domestic compliance market rests on a small number of structural MRV requirements and a handful of design choices on which governments must take a position.

- **Across the case studies, a reliable MRV system rests on sound institutional foundations established in law**. Primary legislation defines covered entities, measurement and reporting obligations, verification standards, and penalties for non-compliance. These institutional arrangements ensure that the data entering the national emissions registry is accurate, which in turn supports the credibility of the country's carbon pricing system.
- **Coordination across international carbon pricing systems is increasingly important**. As mechanisms such as the EU CBAM and Article 6 of the Paris Agreement develop, alignment on MRV standards is becoming a key point of convergence. Countries designing their MRV systems can anticipate this need early and build them to be aligned with MRV required by applicable CBAM. Where established international quantification methods exist, jurisdictions should align with them rather than build from scratch. Quebec's adoption of the WCI protocols is a good example. Looking ahead, the expansion of MRV scope beyond a domestic jurisdiction brings its own challenges, such as including Scope 3 emissions—where data often sits outside the regulated entities (N. Lee, personal communication, 2026).
- **Tiered requirements for different categories of emitters can mitigate the distributional impacts of MRV systems**. The ETSs reviewed in this paper have adopted several approaches to address MRV compliance costs that may fall disproportionately on smaller emitters. These include high emissions thresholds that exclude smaller emitters from the outset; tiered methodologies and default emission factors that hold smaller emitters to less stringent requirements; de-minimis treatment of minor sources; and sector-specific exceptions. Some systems have also tailored their approach to jurisdictional circumstances, offering opt-in opportunities for smaller emitters.
- **The MRV systems reviewed have not yet put GESI and just transition principles into practice in their governance arrangements**. The design of the four case study jurisdictions was largely centred on regulators, verifiers, and industry actors and hence predate today's articulation of just transition principles (European Commission, n.d.; International Emissions Trading Association, 2025a, 2025b). As a result, there is little documented evidence that MRV design itself included inclusive governance mechanisms, such as meaningful stakeholder engagement or tripartite

social dialogue. The benefits of MRV are also unevenly accessible, with smaller, less-resourced entities less able to convert compliance into competitive advantage.

- **Participatory MRV approaches can strengthen community ownership, improve data quality, and build technical capacity**. They can also help reduce the participation and accessibility barriers often associated with MRV. Extending equity and inclusion to the growing MRV workforce can also help ensure that a more diverse range of workers acquires these increasingly valuable skills. More broadly, the just transition lens can operate not only at the level of workers and communities but also among states, ensuring that all countries have a voice in shaping international MRV standards. (Civil society actor, personal communication, 2026).
- **A sequenced approach to MRV lowers the risk of misallocation of allowances, builds regulator and entity capacity, and provides evidence for cap and threshold setting**. Any new compliance market has to decide whether to start with mandatory GHG reporting and set up a carbon price later or launch the pricing system at the same time. Quebec already had a mandatory emissions reporting regulation in place when its cap-and-trade launched. The EU ETS, by contrast, introduced MRV and the carbon price (the obligation to surrender allowances and pay a carbon price) together at its 2005 launch, with no prior reporting pilot to build a facility-level baseline. The same logic applies when the system is extended to new sectors. MRV can be imposed before compliance starts, with verification phased in across later cycles. China applies this approach to its planned expansion into petrochemicals, chemicals, papermaking, and domestic aviation, where entities above 26,000 tCO_2e already conduct MRV in preparation for compliance. The EU now treats the same approach as best practice for sector expansion, applying it across municipal waste incineration, maritime, aviation, and ETS2-regulated entities (R. Geres, personal communication, 2026).
- **Jurisdictions differ in how much verification they conduct in-house versus delegate to accredited third parties**. China conducts its own verification alongside third-party verifiers for all emitters. The EU ETS and Quebec instead outsource to accredited third parties under international standards. Another approach is to combine the two. Quebec layers a government reverification on top of third-party verification and routinely catches errors the verifiers miss. Some jurisdictions take a risk-based approach to decide which emitters' reports to verify internally. Others choose to verify the data of all covered emitters. Regulator capacity and risk of errors are key factors in which route each jurisdiction takes. Where verifier capacity is thin, an in-house model is a workable choice that scales with jurisdiction size (R. Geres, personal communication, 2026).
- **A reported tonne should mean the same thing across emitters and over time, which requires the same methodologies applied system-wide**. Harmonized rules under the EU's Monitoring and Reporting Regulation keep allowances comparable across member states; admitting offsets into a compliance market requires the offset tonne to meet a comparable standard; and cross-border linking of ETSs depends on similar MRV protocols.

- **MRV systems can build on existing institutional infrastructure such as installation-permitting regimes and energy-tax administrations**. Reusing these existing structures streamlines the process of developing an MRV system, as operators have access to shared data flows that can inform scoping decisions from the start. The same logic extends to verification, where existing accreditation systems can be reused. Mapping adjacent legal regimes early, especially energy taxation, also helps align monitoring deadlines.
- **Transparency at every stage of the MRV process, from rule-setting to reporting to verification, is the principal safeguard against data integrity failures and a foundation of system credibility**. Clearly published rules also make compliance simpler for covered entities (N. Lee, personal communication, 2026). In terms of emissions reporting, China, the EU, and others have all faced incidents of data fraud or errors. Transparency makes reported emissions data easier to verify. It creates layers of scrutiny and makes information accessible to the public, who can also uphold accountability. Timely and accessible public data is essential for affected communities and civil society to monitor whether the costs and benefits of carbon pricing are equitably distributed. This is a just transition consideration that transparency in MRV directly enables. Language and international coordination are also closely tied to transparency (Government Official, Alberta, personal communication, 2026). Moreover, CBAM requires countries to have transparency requirements comparable to the EU ETS. Building transparency in as a key pillar of a domestic MRV system therefore also enables smoother cross-border coordination (R. Geres, personal communication, 2026).
- **MRV systems must be designed for change**. The methodologies, emissions factors, and reporting requirements they rely on all evolve over time. The regulatory architecture has to accommodate that without legislative gridlock. MRV programs should be built to allow regular updates, since they improve continually through experience, trial and error, and changing environmental circumstances. Quantification methodologies and emissions factors, especially, need to be continuously updated. In cases where quantification methodologies are embedded in regulations and statutes, updating the methodologies has been a significant administrative burden (V. Leblond & O. Lacroix, personal communication, 2026).
- **MRV is widely framed as a compliance tool and cost, but the same set of obligations can also generate market access, reputational, and revenue benefits**. Regulated entities may view MRV favourably or unfavourably. Either way, strong compliance can make a firm more competitive. It can build a reputation for sound emissions management, support a credible emission reduction plan, and generate revenue from selling surplus allowances to others (N. Lee, personal communication, 2026). Framed well, MRV can be understood as institutional infrastructure that provides firms the opportunity to benefit from the carbon pricing system.

5.2 Recommendations

To put credible, internationally recognized MRV institutions in place, governments can

- build the institutional capacity to design, implement, and enforce MRV obligations, retaining in-house capacity to recheck reported data and catch what verifiers miss;
- ensure a sufficient pool of competent verifiers, accredited domestically where possible;
- extend institutional design consultations beyond regulated industry to include labour and community representatives from the outset;
- model domestic MRV standards on existing global standards to increase coordination potential with other ETSs. Establishing consistency and transferability with existing international carbon pricing mechanisms can minimize coordination costs and avoid extra administrative burdens.

To design an MRV system proportionate to emitters and tailored to jurisdictional context, governments can

- incorporate tiered MRV requirements based on the size and capacity of the emitter to minimize disproportionate burdens on smaller facilities; require simpler methods from smaller emitters, such as using standardized emissions factors; require more accurate and technically advanced approaches from larger emitters.
- begin with mandatory GHG reporting and only attach a price once 2 to 3 years of MRV data are in hand. Impose monitoring and reporting first, then phase in verification and compliance obligations across subsequent cycles.
- apply the same staged approach each time a system extends to a new sector.
- apply the same quantification methodologies across all covered entities, so reported tonnes stay comparable.
- align with established international methods where they exist; where none exists, default to mass-balance or similarly robust approaches.
- address measurement uncertainty and non-continuous data in a reasonable, defensible way, as these are unavoidable features of any MRV system.
- build MRV on existing infrastructure, such as environmental taxation and accreditation bodies, mapping adjacent legal regimes early so scope and reporting deadlines align with the infrastructure already in place.

To ensure their MRV systems are transparent and adaptable, governments can

- publish all installation-level data on a consistent basis, unless there is a clear case for confidentiality;
- build in transparency measures that are compatible with existing carbon pricing mechanisms, such as EU CBAM, to facilitate easier coordination;
- place regulations in administrative decisions instead of legal statutes in areas of the MRV system that will continue to evolve. Elements with the steepest learning

curve, quantification methodologies in particular, should sit in instruments such as ministerial guidelines that are easily updated;

- keep quantification methodologies easily updatable so they can be revised as techniques advance and industry and stakeholder feedback comes in;
- communicate MRV benefits alongside compliance obligations, so regulated entities engage with the system as more than a cost burden.

To advance equity, inclusion, and just transition through MRV design, governments can

- embed GESI and just transition considerations into MRV methodologies, design and implementation processes, certification frameworks, and offset credit issuance processes, especially in carbon pricing mechanisms where offsets can fulfill a significant portion of compliance obligations;
- collect and report disaggregated data (by sex, age, disability status, Indigenous identity, and other relevant characteristics), so distributional outcomes can be measured and assessed over time;
- build community capacity before market entry, ensuring that marginalized and geographically isolated communities, including Indigenous Peoples, can meaningfully participate in and benefit from MRV systems;
- establish domestically accredited verification bodies to reduce prohibitive international verification costs for community-based actors.

6.0 Conclusion

This report examined how MRV operates across the main carbon pricing instruments and what governments designing a domestic compliance market can draw from international experience. It paired a conceptual framework with case studies of Quebec, Alberta, China, and the EU ETS.

The central finding is that MRV systems converge on a common technical core while differing in scope, stringency, and the balance between in-house and third-party verification. For a government building a new compliance market, the high-level answer is to anchor MRV in primary legislation, begin with mandatory reporting before attaching a carbon price, keep the burden proportionate through tiering and thresholds, reuse existing institutional infrastructure, and align with international standards so the system is recognized abroad.

At the same time, the report highlights that MRV is more than a technical system. Its design influences who participates, who bears compliance costs, and who benefits from carbon pricing, making GESI and just transition integral to effective MRV rather than optional considerations. This extends to who helps design MRV systems in the first place. The four case studies show limited evidence of tripartite engagement (government, employers and workers) that just transition guidelines call for. Embedding these principles early can strengthen an MRV system's credibility, legitimacy, and durability. Approached this way, MRV is less a compliance cost than the institutional foundation on which a credible and equitable carbon price depends.

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Appendix A. List of Interviewees

The following experts were interviewed or consulted for this study.

Interviewee	Affiliation	Date
Sarah Cosgrove	Environment and Climate Change Canada	June 2026
Roland Geres	FutureCamp	June 2026
Olivier Lacroix	Quebec Ministry of Environment, Fight Against Climate Change, Wildlife and Parks	June 2026
Leandra Langlois	Environment and Climate Change Canada	June 2026
Vicky Leblond	Quebec Ministry of Environment, Fight Against Climate Change, Wildlife and Parks	June 2026
Nelson Lee	Green Sky Sustainability Consulting, Inc.	June 2026
Michael Pahle	Potsdam Institute for Climate Impact Research	June 2026
Machtelt Oudenes	SQ Consult	July 2026
Sayuri Shirai	Asian Development Bank	June 2026
Anonymous	Government official, Alberta, Canada	June 2026
Anonymous	Development partner representative	June 2026
Anonymous	Civil society actor	June 2026
Anonymous	Government official, Environment and Climate Change Canada	June 2026

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