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RALI GHG MRV Harmonization Framework

Energy Sector Guide

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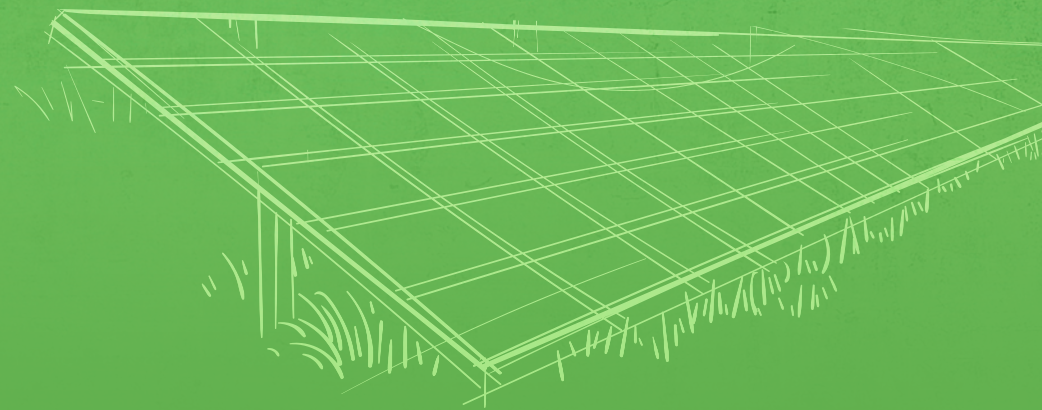

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For more information on the Resources to Advance LEDS Implementation (RALI) project, please visit climatelinks.org/projects/rali.

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Contents

Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
BAU	Business as usual
BUR	Biennial Update Report
CAR	Climate Action Reserve
CDM	Clean Development Mechanism
CH_4	Methane
CNG	Compressed natural gas
CO_2	Carbon dioxide
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LEDS	Low Emission Development Strategies
MOU	Memorandum of understanding
MT	Metric tons
MRV	Measurement, reporting, and verification
MSW	Municipal solid waste
NAMA	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
N_2O	Nitrous oxide
RALI	Resources to Advance LEDS Implementation
T&D	Transmission and distribution
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCS	Verified Carbon Standard

Glossary

Activity Data
Data measuring human activity that results in greenhouse gas (GHG) emissions or removals. Activity data may include fossil fuel combustion, waste generation, or land-use changes.

Bottom-Up GHG Accounting
Data, methodologies, and processes used for project-level measurement, reporting, and verification (MRV) for GHG mitigation activities.

Causal Chain
A flow chart of a specific mitigation activity that identifies and maps the activity's specific actions, outcomes, and associated GHG impacts.

Data Attribute
A characteristic of a data element (see definition below) such as the source of the data and frequency of collection.

Data Element
A variable that is used to calculate emissions in national inventory or mitigation MRV methods.

On-site generation
Generation of heat or electricity on-site for own use rather than imported from the electricity grid.

Emission Factor
The average emission rate of a GHG relative to a unit of activity. Together with activity data, emission factors are key components used to estimate emissions.

Key Category
A category of GHG emissions or removals that is prioritized due to its influence on the total absolute level of emissions, emission trends, or uncertainty associated with the emissions.

Metric
A data element that is often used to track GHG and other impacts of an activity, particularly in mitigation MRV accounting.

Pathway
The way in which mitigation activities impact GHG inventories. Pathways can impact multiple Intergovernmental Panel on Climate Change (IPCC) source/sink categories or a single IPCC source/sink category in GHG inventories.

Tiers
A three-tiered classification system developed by the IPCC to distinguish different levels of methodological approaches to estimate GHG emissions. Tiers are based on data availability and the level of analytical complexity in approaches used to estimate GHG emissions. Tiers include IPCC default (Tier 1) and country-specific (Tier 2 and Tier 3) methods, which are typically more accurate.

Top-Down GHG Accounting
Data, methodologies, and processes used to measure GHG emissions as part of a country's national inventory process.

Introduction

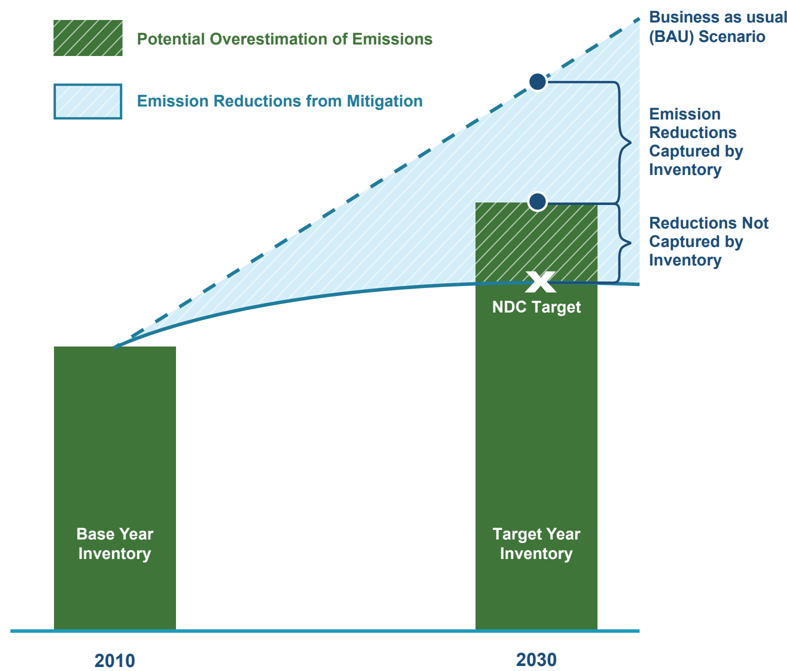
Countries around the world have set ambitious targets for reducing greenhouse gas (GHG) emissions as part of their nationally determined contributions (NDCs) under the 2015 Paris Agreement on climate change. NDCs serve as a significant catalyst for mitigation actions across sectors and at all scales, from local projects to national policies. These developments enhance the need for transparent reporting on the impact of diverse mitigation actions.

The Challenge of Harmonization

As countries implement mitigation activities and develop methods to measure the impact of these activities, they need to also monitor progress toward their respective NDCs.

One way to do that is to ensure that GHG effects from mitigation activities are captured in national GHG inventories. However, measurement, reporting, and verification (MRV) methods for mitigation activities vary by project and are often distinct from MRV methods for national inventories, which are typically structured to comply with international reporting requirements. This may result in over- or under-estimated national emission levels. Underestimating emission reductions achieved could falsely indicate that countries are not meeting their reduction targets and may affect investment in future mitigation activities if returns on these investments are not demonstrated (see *Figure 1*).

Figure 1: Incorporating Mitigation into National GHG Inventories



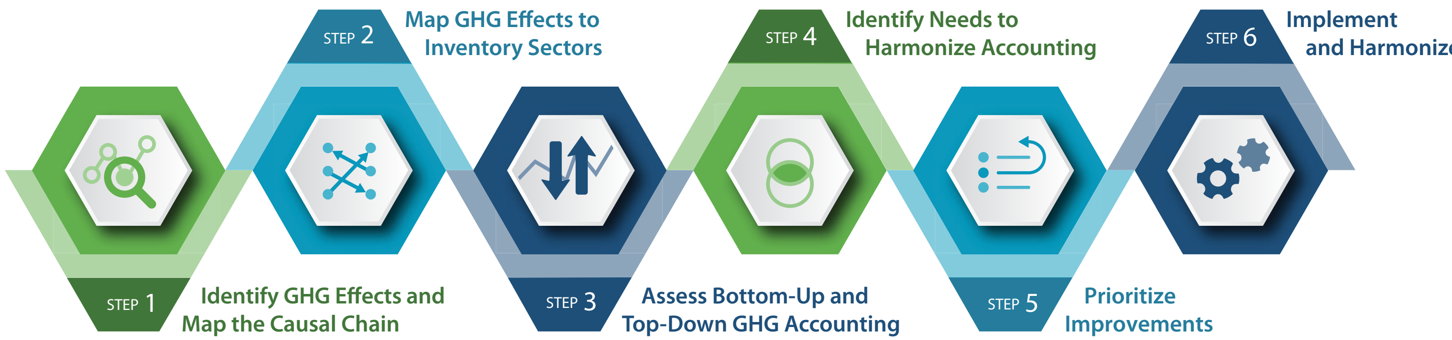
If national inventories do not reflect the full extent of mitigation activities, national emission trajectories may not demonstrate progress toward a country's NDC target.

The RALI GHG MRV Harmonization Framework

The RALI GHG MRV Harmonization Framework ("Harmonization Framework") is a six-step process designed to help national inventory compilers, mitigation activity implementers, and other stakeholders align MRV methods for GHG mitigation activities (i.e., "bottom-up" GHG accounting) with national GHG emission inventories (i.e., "top-down" GHG accounting) (see *Figure 2*).

The Harmonization Framework provides an approach for these users to identify accounting discrepancies, understand why these discrepancies are occurring, set priorities to address the most significant issues, and implement a plan to resolve these problems. Importantly, the Harmonization Framework is designed to be a sustainable, "turn-key" approach that allows mitigation activity and emission inventory teams to continuously improve their GHG accounting. The Harmonization Framework is designed to improve the accuracy and transparency of GHG emissions reporting and to enhance the ability of stakeholders to use this reporting for tracking GHG effects from mitigation actions.

Figure 2: The RALI GHG MRV Harmonization Framework



Purpose of this Document

This document provides instructions on how to apply the Harmonization Framework to mitigation activities within the Energy sector. It is part of a series of Harmonization Guidance documents that demonstrate the harmonization technique across inventory sectors. For more general guidance on the Harmonization Framework and templates to apply the approach, consult the General Framework Guide.[1] The Framework's intended audience includes national inventory compilers, mitigation activity implementers, and related stakeholders.

[1] See the RALI GHG MRV Harmonization Framework: A General Framework Guide. Available online at: https://www.climatelinks.org/resources/rali-ghg-mrv-harmonization-framework

Getting Started with the Framework

Many countries have prioritized mitigation activities to meet their NDC commitments. In order to apply the Harmonization Framework to these activities, users must first select a specific mitigation activity to analyze and determine who to engage at each step of the Framework's process (see *Figure 2*).

To select mitigation activities for applying the Framework, users should consider factors such as:

- Availability of information about the activity
- Availability of established MRV methods to estimate emission reductions
- Existing MRV and stakeholder activity underway
- Mitigation potential and relative contribution to NDC goal (if applicable)
- Impact to key categories or priority sectors within the national GHG inventory
- Overlap with national or subnational climate change policy and initiatives

Steps 1 through *4* of the Framework are more analytical and may be appropriate for an inventory developer or mitigation activity implementer to apply, provided they have access to both mitigation MRV and national inventory information. *Steps 5* and *6*, however, include decisions to be made by the mitigation MRV and national inventory teams, along with governing ministries and other relevant stakeholders involved in decision-making. These steps require engaging broader stakeholder groups for implementation. Given the differences between steps, users should identify the appropriate stakeholders to involve throughout the process.

Energy Sector Overview

Energy for heating, power, lighting, and transport is required to meet basic human needs. Social and economic development depends on these services to meet increasing energy demands. As much of this energy is generated from fossil fuels, the Energy sector is typically a significant source of GHG emissions in most countries. This sector represents the largest source of global GHG emissions, consisting primarily of carbon dioxide (CO_2) emissions from fossil fuel combustion.[2]

While fossil fuels continue to dominate the global energy supply, the potential for low- or zero-carbon alternatives to meet energy needs is expanding. There are many mitigation strategies to reduce GHG emissions from energy systems while still satisfying the global demand for energy, increasing energy access, and securing a resilient energy supply. Moreover, mitigation activities in the Energy sector have become a major focus for countries and supporting international partners as they make plans to achieve the targets set in their NDCs.

[2] See the IPCC Fifth Assessment Synthesis Report. Available online at: https://ar5-syr.ipcc.ch/topic_observedchanges.php

The importance of a sustainable energy supply, the potential for significant reductions in Energy sector emissions, and the inclusion of energy-related GHG mitigation activities in NDC commitments make mitigation activities in this sector good candidates for the Harmonization Framework. This document illustrates each step of the Harmonization Framework for three categories of mitigation activities in the Energy sector, including electricity generation, energy efficiency, and transport activities, defined below.

- **Electricity generation** mitigation activities including installing and using renewable energy, switching to lower-carbon fuels, or using other sources to generate low- or zero- carbon electricity.
- **Energy efficiency** mitigation activities enable less energy to be used to meet the same need and include activities such as increasing the efficiency of buildings and power plants and reducing losses from electricity transmission and distribution systems.
- **Transport** mitigation activities can reduce reliance on fossil fuels by increasing fuel efficiency, shifting to less GHG-intensive alternatives, or reducing vehicle use.

Energy sector mitigation activities can impact several national GHG source and sink categories. These GHG inventory categories are defined by the *2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines* and primarily include those in the Energy; Agriculture, Forestry, and Other Land Use (AFOLU); and Waste sectors. Within the Energy sector, mitigation activities can reduce demand for fossil fuels, resulting in a decrease in GHG emissions from the production, transport, and combustion of fossil fuels, as well as a decrease in the carbon intensity of these activities. Some energy mitigation activities may also impact other sectors, such as AFOLU and Waste. For example, energy-related mitigation activities may impact GHG emissions within the AFOLU sector by increasing agricultural production to supply alternative fuels, or the Waste sector by using of waste management byproducts to generate energy.[3]

[3] Refer to the *2006 IPCC Guidelines*, Volumes 2, 4, and 5 for definitions of each sector and source category. Available online at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Applying the Harmonization Framework to the Energy Sector

This document illustrates each step of the Harmonization Framework as applied to the Energy sector for three categories of mitigation activities—electricity generation, energy efficiency, and transport activities (see *Table 1*). Even with a wide variety of mitigation actions and diversity in policies or actions, this guide demonstrates that there are a limited number of pathways for reducing GHG emissions, as captured in a national inventory. *Step 1* and *Step 2* of this guide define common energy mitigation activities and their GHG impacts and identify which IPCC sectors and source categories are likely to be impacted. *Step 3* describes common top-down and bottom-up accounting methods in the Energy sector and identifies common areas of overlap. While recommendations for harmonization are specific to each country's circumstances and individual mitigation activities, *Step 4* discusses common harmonization challenges and opportunities that may arise in the Energy sector. Finally, *Step 5* and *Step 6* provide considerations for countries to prioritize and implement improvements to realize harmonization opportunities between mitigation and inventory accounting methods and processes.

For each mitigation activity in the Energy sector, this guide will help users to understand:

- What are the GHG impacts of the activity?
- How does the activity intersect with the national inventory?
- What are common data elements between mitigation project and inventory accounting?
- Where are there opportunities to align project and inventory accounting data, methods, and processes?

Step 1: Identify GHG Effects and Map the Causal Chain

The mitigation activities discussed in this Energy sector guidance reduce fossil fuel consumption to generate electricity and reduce end-use energy consumption—all of which reduce GHG emissions and the GHG intensity of electricity generation systems. The GHG effects of these activities vary based on the specific mitigation project. For example, a biomass energy project can impact AFOLU GHG emissions, whereas a wind turbine only impacts the Energy sector. This guidance covers direct impacts to the Energy sector.

Table 1 summarizes common categories of energy mitigation activities that a country may implement. The mitigation activity a country selects to harmonize may fall into more than one of these categories. Throughout this guidance, users should review the discussion of the mitigation categories that are most relevant to their selected activity.

Step 1: A wind energy project mainly affects Energy sector GHG emissions, whereas other energy mitigation projects (e.g., biomass energy) have additional impacts in the AFOLU sector.

In *Step 1*, users will:

- Identify the category of mitigation activity or activities that are most similar to their selected mitigation activity.
- Map the specific outcomes of their mitigation activity and associated impacts on GHG emissions using the simplified causal chains in this guidance as examples.

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STEP 2
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Table 1: Common Energy Mitigation Activities

Mitigation Activity Category	Sub-Category	Description	Example Mitigation Activities
Electricity Generation	Renewable Energy	Implementation or installation of zero-carbon electricity generation technologies, or low-carbon electricity generation through the use of biofuels or biomass co-firing	◦ Installation of renewable energy capacity (e.g., solar, wind, biomass) to supply electricity for on-site use or to connect to the grid
	Fuel Switching	Substitution of GHG-intensive energy sources for less GHG-intensive energy sources to reduce the carbon intensity of the electricity grid	◦ Switching from coal to natural gas in an existing fossil-fuel-fired power plant
	Alternative Sources of Energy	Implementation of alternative sources of energy such as waste-to-energy projects that reduce methane emissions and generate energy	◦ Installation of waste-to-energy technologies to generate heat or electricity from incinerating municipal solid waste ◦ Introduction of a gasification process to use solid waste to produce synthesis gas that is easily combustible in a gas turbine/engine to generate energy ◦ Implementation of landfill gas-to-energy projects to capture methane and use it to generate energy
Energy Efficiency	Building Energy Efficiency	Improved efficiency of end-use equipment through technology upgrades or replacements that reduce the amount of energy consumed by the end user, as well as the implementation of practices that conserve energy and structural changes to buildings to reduce energy losses	◦ Energy efficiency improvements in lighting, appliances, and other equipment to reduce building energy consumption ◦ Improvements to building envelope (e.g., windows, insulation) to reduce building energy consumption ◦ Energy efficient building codes
	Transmission and Distribution Systems	Improved efficiency of existing electricity transmission and distribution systems by improving performance or reducing technical losses	◦ Increased use of improved transformers and distributed power generation to reduce losses ◦ Regulations that require or incentivize more efficient electricity transmission and distribution systems

Mitigation Activity Category	Sub-Category	Description	Example Mitigation Activities
Energy Efficiency *(continued)*	Power Plant Efficiency	Improved efficiency of electricity generation at new or existing power plants	• Installation of cogeneration plants (i.e., combined heat and power plants) that generate electricity in addition to providing heating/cooling • Replacing a coal-fired power plant with a more efficient natural gas combined-cycle power plant
Transport	Fuel Efficiency	Implementation of fuel and technology alternatives to reduce conventional fuel use in transport activities	• Fuel efficiency standards for cars and trucks
	Fuel Switching	Substitution of conventional fuel vehicles for less GHG-intensive fuels to decarbonize the transport sector	• Deployment of electric, compressed natural gas (CNG), or biofuel vehicles that replace conventional fuel vehicles
	Transportation Demand Management	Reduction of vehicle fuel use by shifting to more energy efficient transportation modes, and integration of sustainable transportation practices in urban development projects	• Modal shift to transportation modes with lower GHG emissions per passenger-kilometer, such as public transportation, biking, or walking • Urban development transportation planning projects (e.g., walking communities, transit connectivity), leading to reduced use of single-occupancy vehicles
Other[1]	Carbon Capture and Storage	Use of technologies to capture, transport, and store carbon dioxide underground that would otherwise be emitted in the atmosphere	• Retrofitting an existing power plant to introduce post-combustion carbon capture technologies to remove carbon dioxide from flue gas after combustion
	Fugitive Mitigation Technologies and Practices	Implementation of technologies and practices to reduce fugitive methane emissions in natural gas and oil systems that result from equipment and process leaks and venting in wells, storage tanks, pipelines, and production equipment	• Equipment upgrades to reduce leakages in natural gas infrastructure, such as substituting compressed air for natural gas within pneumatic systems • Capturing methane vented during oil production to be used for energy • Improvements to direct inspection and maintenance of equipment to detect and repair leaks

[1] "Other" energy mitigation activities are not included as part of this guidance.

1.1 Map Impacts of Energy Mitigation Activities Using Causal Chains.

Each mitigation activity described in *Table 1* results in specific outcomes and impacts on GHG emissions. Causal chains are flow charts that illustrate the outcomes and GHG effects of a mitigation activity and help to define the boundaries of the activity and analysis.[4] Causal chains also demonstrate that mitigation activities can often impact GHG emissions through multiple pathways, and several mitigation activities may result in the same GHG impacts. Simplified causal chains for electricity generation, energy efficiency, and transport mitigation activities are presented in *Figure 3* through *5*. The simplified primary and secondary outcomes presented in these figures represent the specific ways the activities impact GHG emissions.

The causal chains presented in this guidance are not exhaustive: they do not capture all potential outcomes of these activities, but rather the main pathways and outcomes that impact GHG accounting. There may be additional outcomes and rebound effects of Energy sector mitigation activities that are beyond the scope of the causal chains presented in this guidance.

What's Included in the Causal Chain:

Activity: mitigation policy or action

Outcomes: resulting changes in behavior, technology, processes, or practices caused by the activity

GHG effect: changes in GHG emissions that occur as a result of the outcomes

- *Energy industries sector*
- *Residential, commercial, and industrial sectors*
- *Transport sector*
- *AFOLU sector*

[4] For more detailed instructions on mapping causal chains, refer to Chapter 6 of the GHG Protocol *Policy and Action Standard*.

Figure 3: Causal Chain for Selected Electricity Generation Mitigation Activities

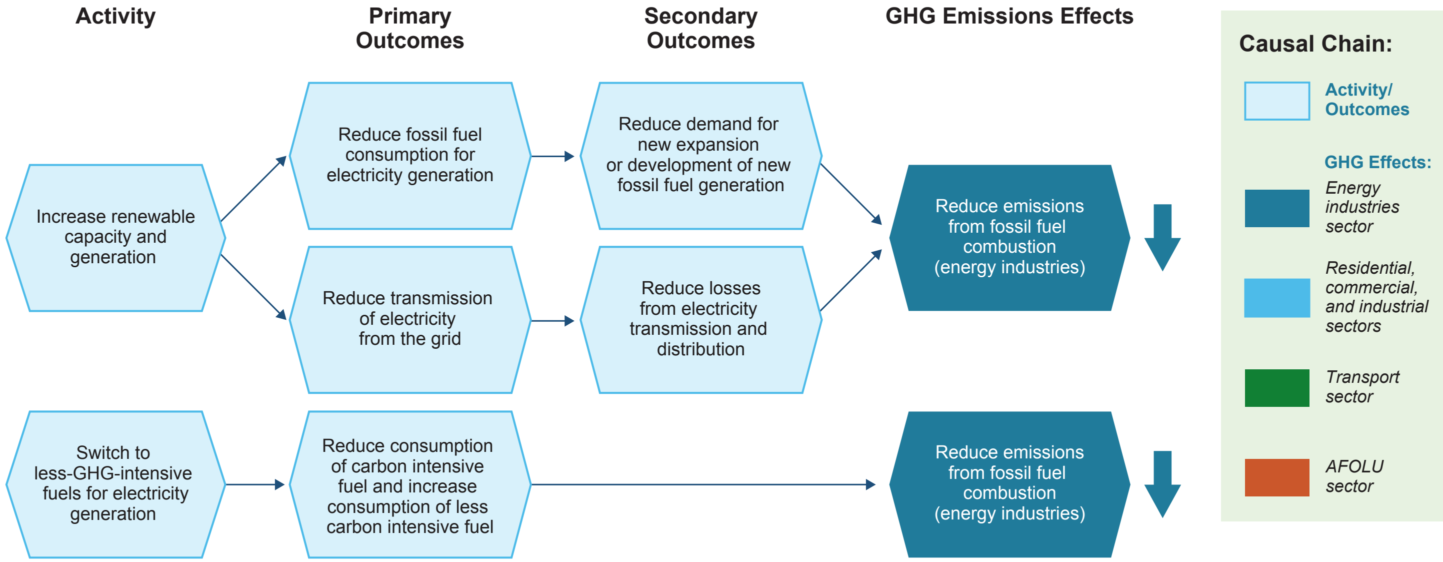


Figure 4: Causal Chain for Selected Energy Efficiency Mitigation Activities

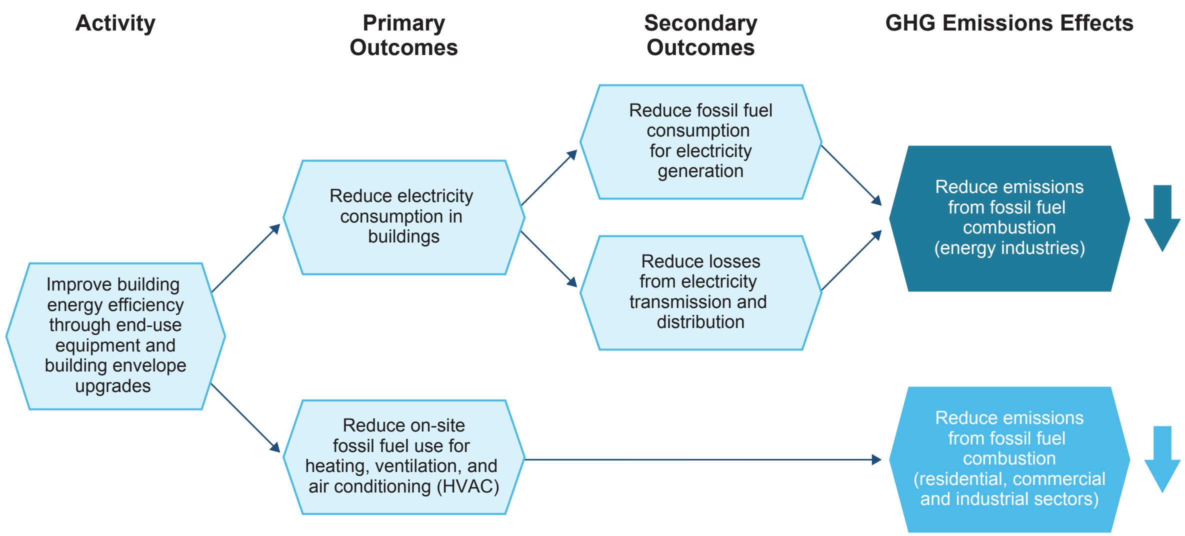
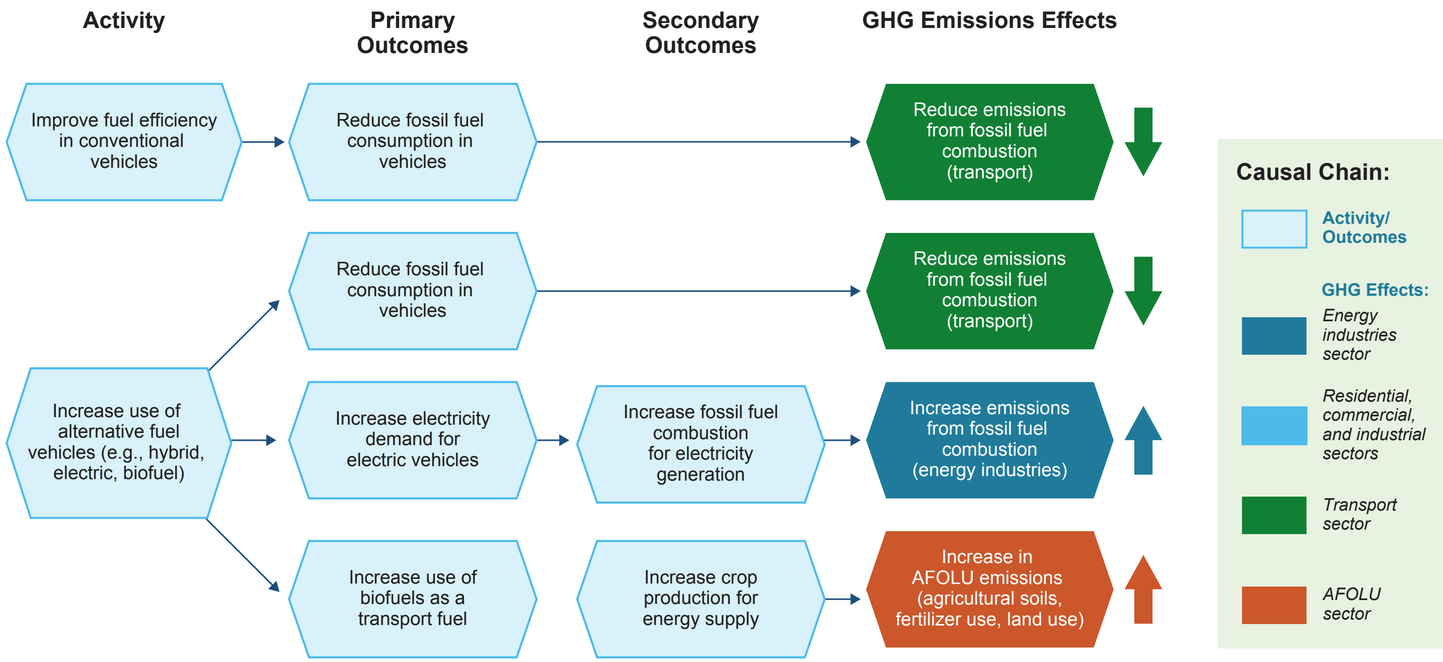


Figure 5: Causal Chain for Selected Transport Mitigation Activities



After completing *Step 1*, users have:

- Identified the category of mitigation activity or activities that are most similar to their selected mitigation activity.
- Mapped the specific outcomes of their mitigation activity and associated impacts on GHG emissions using the simplified causal chains in this guidance as examples.

Step 2: Map GHG Effects to Inventory Sectors

The next step in the Framework is to map the GHG effects identified in *Step 1* to GHG inventory sectors and source categories. For national inventories, these sectors and source categories are defined by the *2006 IPCC Guidelines*, which describe the activities that result in GHG emissions under each category and provide methods to estimate national GHG emissions and sinks (IPCC 2006).

2.1 Map Mitigation Activities to Inventory Sectors

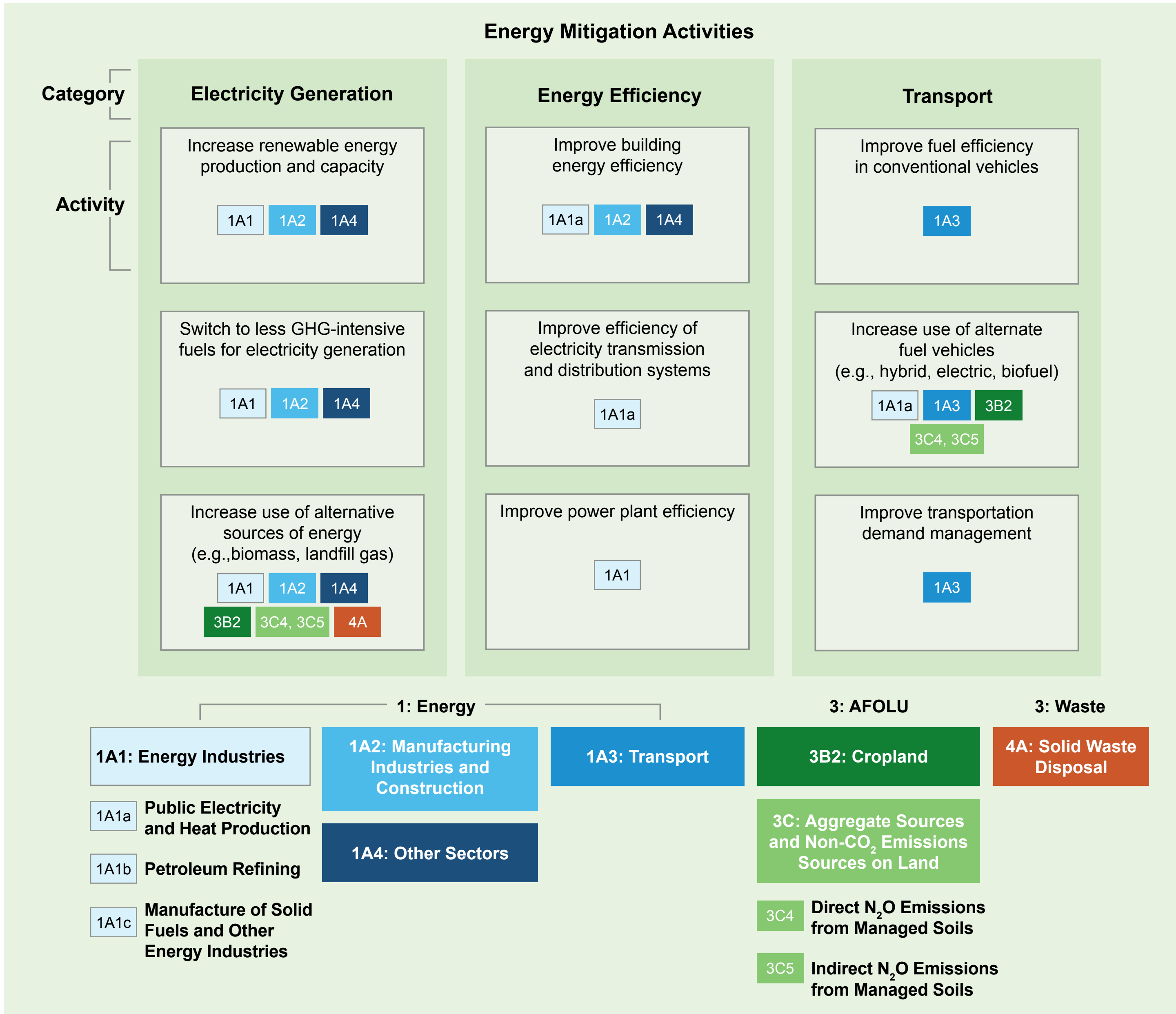
Figure 6 illustrates which IPCC source and sink categories are impacted by the mitigation activities identified in *Table 1* for each of the mitigation pathways. This is not an exhaustive mapping, but rather shows IPCC categories that are most likely to capture direct impacts from these activities. Activities may have indirect or upstream impacts on other IPCC categories, such as in the Industrial Processes and Product Use (IPPU) sector. For instance, increasing renewable energy generation from solar panels might increase emissions from the production of solar photovoltaic panels, which impacts GHG emissions from the IPPU sector. This guidance covers IPCC categories that are likely to be directly impacted by the mitigation activities listed in *Step 1.*

Step 2: A project that involves switching from gasoline vehicles to low-carbon alternatives such as biofuels and CNG reduces emissions from fossil fuel combustion in the transport sector.

In *Step 2*, users will:

- Identify the specific GHG pathway through which each mitigation activity impacts the inventory.
- Map the GHG effects identified in *Step 1* to GHG inventory sectors and source/sink categories.

Figure 6: Mitigation Activities Mapped to IPCC Sectors



2.2 Define Pathways to Reduce GHG Emissions as a Result of Energy Mitigation Activities

The causal chains in *Step 1* and the mapping to inventory sectors in *Step 2.1* demonstrated that Energy sector mitigation activities and their specific outcomes result in common GHG effects, including:

- Reduce emissions from fossil fuel combustion (energy industries)
- Reduce emissions from fossil fuel combustion (residential, commercial, and industrial sectors)
- Reduce emissions from fossil fuel combustion (transport)
- Impacts to other categories (AFOLU, IPPU, waste)

These represent GHG inventory pathways. A "**pathway**," as used here, is the way in which a mitigation activity affects emissions and ultimately a GHG inventory. Mitigation activities can impact GHG emissions through multiple pathways. For example, mitigation activities that involve the use of biomass have two different pathways: 1) reducing emissions from fossil fuel combustion (IPCC Energy sector Source Category 1A), or 2) increasing emissions from crop production and fertilizer use (IPCC AFOLU sector Source Categories 3B2, 3C4, and 3C5). While there are a variety of Energy sector mitigation activities, the number of pathways that impact an inventory are limited. Specific pathways for the Energy sector mitigation activities listed in *Table 1* are described below.

Pathway 1. Reduce emissions from fossil fuel combustion for electricity generation

This pathway involves reducing emissions by reducing fossil fuel consumption for electricity generation. This impact can be achieved by activities such as:

- ***Grid-connected renewable electricity capacity/generation.*** Switching from fossil-fuel-powered electricity generation to low- or zero-carbon renewable electricity reduces the amount of fossil fuels combusted to produce electricity and reduces the carbon intensity of the grid. Expansion of renewable energy also may reduce upstream emissions from fossil fuel energy development, such as resource extraction and refining.
- ***On-site (distributed) renewable energy generation.*** Switching from grid-supplied electricity to on-site energy generation from cleaner sources such as renewables (e.g., installing solar panels on the roofs of buildings or homes) reduces consumption of fossil-fuel-powered electricity from the grid.
- ***Fuel switching.*** Switching from higher-carbon fossil fuels (e.g., coal) to lower-carbon fossil fuels (e.g., natural gas) reduces total emissions resulting from generation of the same amount of electricity. Increasing the share of less GHG-intensive fuel types in grid-supplied electricity reduce the overall carbon intensity of the grid.

- ***Alternative energy sources.*** Waste management practices such as waste-to-energy and methane gas recovery can provide energy for waste facilities to use on-site and reduce the need for grid-supplied electricity and fossil fuels to generate that electricity.
- ***Electricity transmission and distribution efficiency.*** Improvements to the electricity transmission and distribution systems, such as increased use of improved transformers and distributed power generation, reduce electricity losses and therefore reduce emissions from fossil fuel combustion.
- ***Building energy efficiency.*** Improving the efficiency of end-use equipment such as lighting and appliances reduces the amount of electricity used in buildings, which reduces fossil fuel combustion to produce electricity. Improving the structural integrity of buildings through improved insulation to prevent energy waste can reduce demand for energy and energy-related emissions.
- ***Demand-side management.*** In addition to end-use equipment improvements discussed above, additional demand-side management activities focus on reducing energy use (typically electricity) by consumers through behavioral change.
- ***Power plant efficiency.*** Implementing process efficiency improvements at power plants can reduce fossil fuel combustion for the generation of electricity for the grid.

All of these activities impact *IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production.*

Pathway 2. Reduce emissions from on-site fossil fuel combustion in the energy industries, residential, commercial, and industrial sectors

This pathway includes reducing fossil fuel consumption for electricity or heat generated on-site by the residential, commercial, and industrial sectors, as well as on-site combustion for the generation of electricity/heat for own use by the energy industries sector (e.g., natural gas plants, refineries). This can be achieved by activities such as:

- ***On-site (distributed) renewable energy generation.*** Switching from fossil fuels to renewables for on-site electricity and heat generation reduces fossil fuel combustion on-site for residential, commercial, and industrial facilities. For example, switching from diesel generators to renewable energy generation at a commercial facility reduces fossil fuel combustion emissions at that facility. *IPCC Source Category: 1A2 – Manufacturing Industries and Construction, and 1A4 – Other Sectors*
- ***Alternative energy sources.*** Waste management practices such as waste-to-energy and methane gas recovery can provide energy for waste facilities to use on-site and reduce the need for on-site fossil fuel combustion. *IPCC Source Category: 1A2 – Manufacturing Industries and Construction, and 1A4 – Other Sectors*
- ***Building energy efficiency (on-site combustion).*** Improving the building envelope (e.g., improved insulation to reduce energy losses) reduces energy demand for HVAC, which reduces fossil fuel use at the building if energy

or heat for these purposes is generated on-site. *IPCC Source Category: 1A2 – Manufacturing Industries and Construction, and 1A4 – Other Sectors*

- ***Power plant efficiency.*** Implementing efficiency improvements at power plants reduces on-site fossil fuel combustion for energy industry operations, outside of generating electricity for the grid. *IPCC Source Category: 1A1b – Energy Industries: Petroleum Refining, and 1A1c – Energy Industries: Manufacture of Solid Fuels and Other Energy Industries*

Pathway 3. Reduce emissions from fossil fuel combustion in the transport sector

Reducing fossil fuel consumption in the transport sector can be achieved by activities such as:

- ***Fuel efficiency.*** Improving the fuel efficiency of conventional vehicles reduces the fuel consumed to travel the same distance, which reduces the quantity of fossil fuels consumed for transportation. *IPCC Source Category: 1A3 – Transport*
- ***Reductions in vehicle distance traveled (e.g., mode shifting and land-use changes).*** Mode shifting from cars to biking or walking reduces overall transport fuel consumption by reducing the distance traveled by single-occupancy vehicles. Mode shifting from cars to public transportation such as buses decreases emissions from single-occupancy vehicles but may increase emissions from buses. However, net emissions would likely still be reduced on a passenger-kilometer basis. *IPCC Source Category: 1A3 – Transport*
- ***Fuel switching to alternative fuels.*** Switching from higher-carbon fuels for transportation (e.g., gasoline and diesel) to lower-carbon alternatives (e.g., biofuels, CNG, or electric vehicles), reduces carbon emissions. *IPCC Source Category: 1A3 – Transport*
- ***Fuel switching to electric vehicles.*** Switching from conventional fuel vehicles to electric vehicles reduces tailpipe emissions from vehicles; however, it results in additional demand for electricity that may increase stationary combustion emissions if the electricity is largely generated using fossil fuels. *IPCC Source Category: 1A3 – Transport, and 1A1a – Energy Industries: Public Electricity and Heat Production*.

Other GHG Impacts

In addition to energy-related GHG pathways discussed above, mitigation activities can impact other source categories and sectors, as shown in the causal chain. Some examples include the following:

- **In the AFOLU sector:** emissions from fertilizer production and consumption, agricultural soils, and land-use changes may occur as a result of increased production and consumption of biofuels for energy use. Activities that use anaerobic digesters to generate energy may result in decreased emissions from manure management.

- **In the Waste sector:** activities that use waste byproducts as an alternative fuel can also have impacts on emissions from landfills and wastewater treatment.
- **In the Energy sector:** implementation of mitigation measures in oil and natural gas infrastructure reduce methane emissions from gas that previous had been leaking or was being vented.
- **In the Energy and IPPU sectors:** upstream and downstream emissions from manufacturing, installation, operation, and decommissioning of wind turbines, solar photovoltaic panels, and other renewable technologies may occur as a result of increased renewable energy production and capacity.

After completing *Step 2*, users have:

- Identified the specific GHG pathway through which each mitigation activity impacts the inventory.
- Mapped the GHG effects identified in *Step 1* to GHG inventory sectors and source/sink categories.

Step 3: Assess Bottom-Up and Top-Down GHG Accounting

This step summarizes typical components of the national inventory GHG accounting and mitigation activity MRV methods for the Energy sector. For each GHG pathway defined in *Step 2*, this section summarizes primary metrics and accounting methods, and identifies common overlap between top-down and bottom-up data elements in order to help users determine if/how mitigation activities are captured in the current inventory. This step will help establish an understanding of current accounting processes before exploring harmonization opportunities in *Step 4*. Before assessing and comparing the bottom-up and top-down GHG accounting methods for each pathway, it is important to define a consistent boundary[5] for GHG impacts of the selected mitigation activity to ensure an accurate comparison.

Step 3: Bottom-up data for a project that involves switching from coal to natural gas at an existing power plant may not align with top-down methodologies that use survey data to estimate fuel consumption at facilities.

In *Step 3*, users will:

- Identify the primary metrics for each GHG pathway to measure the GHG impacts of the selected mitigation activity.
- Assess and compare the bottom-up and top-down GHG accounting methods and data elements by pathway.

[5] For more information on defining a GHG assessment boundary, refer to Chapter 7 of the GHG Protocol *Policy and Action Standard.*

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3.1 Identify Data Sources and Documentation

Understanding current data sources and documentation helps determine where alignment issues exist between top-down and bottom-up accounting and subsequently helps to identify harmonization opportunities in *Step 4*. *Figure 7* summarizes common data sources for top-down and bottom-up accounting, and shows where data elements are commonly documented. This is followed by a discussion of sources and documentation for top-down and bottom-up accounting.

Figure 7: Top-Down and Bottom-Up Data Sources and Documentation

	Data Sources	Documentation
Top-Down Accounting	• Statistics from ministry of energy or other government agency • Power producers and/or fuel suppliers • Peer-reviewed scientific literature • Commissioned study • IPCC guidelines and/or emission factor database • Expert judgment • Equation or model	• National Inventory Report • Biennial Update Report • National Communications report • Documentation of methods and data, including calculation spreadsheets or archiving systems where activity data and emission factors are stored • National inventory improvement plan
Bottom-Up Accounting	• Direct measurement • Reported value from project implementer • Laboratory testing • Equations or models • Peer-reviewed scientific literature • IPCC guidelines and/or emission factor database	• Project evaluations • NAMA database • Summary reports • Training and capacity-building reports • Sectoral action plans • Mitigation registry

Top-Down Accounting

As documented in national GHG inventories, countries use a variety of data sources for both activity data and emission factors. IPCC defaults are not likely to provide changes in values over time and are not country-specific, and thus may not reflect changing trends in emissions as a result of mitigation activities. Many countries may initially use IPCC default factors, but as countries improve national inventory accounting methodologies they often substitute the default values with those from country-specific data sources that reflect changing trends in the Energy sector. *Table 7* in the *Annex* presents specific data sources commonly used by countries to gather energy-specific data elements.

Bottom-Up Accounting

The methodologies and data used in bottom-up accounting vary by project. If no mitigation activity MRV method exists, internationally accepted guidelines on project GHG MRV accounting can provide the data elements needed to account for GHG emissions at the project level. The methodologies and standards in these guidelines, including those listed below, provide an overview of potential MRV methods to inform the bottom-up assessment, if project-specific MRV does not exist.

- Clean Development Mechanism (CDM)
- GHG Protocol for Project Accounting
- The Gold Standard
- The Climate Registry
- Verified Carbon Standard (VCS)
- Climate Action Reserve (CAR)

Energy-specific GHG MRV methods that were used to inform *Step 3* discussions by pathway are provided in *Table 8* in the *Annex*, listed by mitigation activity category.

3.2 Identify Energy Metrics

"Metrics" are data elements used to track impacts of an activity, such as the effects on GHG emissions, particularly in mitigation MRV accounting. This section defines common metrics for energy mitigation activities, which can inform bottom-up accounting methods. Primary energy metrics are defined in *Table 2* for each GHG pathway.

Table 2: Metrics for Measuring Impacts of Energy Mitigation Activities

Metric	Definition
Pathway 1. Reduce emissions from fossil fuel combustion for electricity generation	
Fossil fuel consumption	Amount of fossil fuel combusted for electricity generation
Grid emission factors	Amount of GHG emissions per unit of electricity generation (i.e., carbon intensity of the grid)
Renewable energy generation	Amount of energy produced by zero-carbon renewable sources (e.g., wind or solar)
Percentage of technical loss from transmission and distribution system	Percentage of electricity lost during transmission and distribution
Municipal solid waste (MSW) incinerated for energy recovery	Amount of municipal solid waste incinerated for energy recovery
Waste gas captured for energy generation	Amount of landfill gas (anaerobic digester gas or other waste byproduct gas) captured to produce energy rather than emitted as vented methane
End-use electricity sales	Retail sales of electricity to the residential, commercial, and industrial end-use sectors
Wood biomass and biofuel consumption	Amount of wood biomass and biofuel combusted for electricity generation
Pathway 2. Reduce emissions from on-site fossil fuel combustion in the energy industries, residential, commercial, and industrial sectors	
Fossil fuel consumption	Amount of fossil fuel combusted for on-site energy generation
Renewable energy generation on-site	Amount of on-site energy produced by zero-carbon renewable sources (e.g., wind or solar)
Energy savings	Amount of energy (electricity or fossil fuel) reduced
MSW incinerated for energy recovery	Amount of municipal solid waste incinerated for energy recovery
Waste gas captured for energy generation	Amount of landfill gas (anaerobic digester gas or other waste byproduct gas) captured to produce energy rather than emitted as vented methane
Wood biomass and biofuel consumption	Amount of wood biomass and biofuel combusted for on-site electricity or heat

INTRODUCTION

STEP 1
Identify GHG Effects and Map the Causal Chain

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STEP 3
Assess Bottom-Up and Top-Down GHG Accounting

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Identify Opportunities to Harmonize Accounting

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Prioritize Improvements to GHG Accounting

STEP 6
Implement and Harmonize

REFERENCES

ANNEX A
Helpful Resources

Metric	Definition
Pathway 3. Reduce emissions from fossil fuel combustion in the transport sector	
Fossil fuel consumption	Amount of fossil fuel combusted for use in transportation
Vehicle distance traveled by vehicle and fuel type	Amount of vehicle distance traveled by vehicle type for conventional and alternative fuels types
Average vehicle fuel efficiency	Average fuel efficiency (in kilometers per gallon) by vehicle type
Alternative fuel consumption in vehicles	Amount of alternative fuels (e.g., biofuels) consumed by vehicles
Number of alternative fuel vehicles	Number of alternative fuel vehicles in the fleet
End-use electricity sales	Retail sales of electricity to the transport sector

3.3 Assess and Compare GHG Accounting Methods and Data Elements by Pathway

The IPCC published top-down accounting methods in the *2006 IPCC Guidelines*, and other organizations publish hundreds of GHG accounting methods for bottom-up mitigation activities. See *Annex Table 8* for a summary of MRV accounting methods for each Energy mitigation activity category discussed within this guidance.

In top-down methodologies, the GHG effects of energy mitigation activities are observed primarily in IPCC Source Category 1A: Fuel Combustion Activities. In general, emissions from this source category are calculated as follows, for each fuel type (IPCC 2006):

$$CO2\ Emissions_{fuel} = Fuel\ Consumption_{fuel} \times Emission\ factor_{fuel}$$

Activity Data — Emission Factor

$$CH4\ and\ N2O\ Emissions_{fuel} = Fuel\ Consumption_{fuel} \times Emission\ factor_{GHG,\ technology,\ fuel}$$

Activity Data — Emission Factor

Methods can vary by tier, data elements, data sources, frequency of data collection, and other factors. For example, a Tier 1 method for calculating GHG emissions from fossil fuel combustion is the simplest, using default average emission factors by fuel type. A Tier 2 method requires a country-specific emission factor for each fuel type and takes into account the carbon content of fuels used, carbon oxidation factors, and fuel quality, and ideally any variability in these emission factors over time. A Tier 3 method uses emission factors that are not only country-specific, but also vary by technology type, taking into account combustion technology, operating conditions, control technology, fuel efficiency, and fuel rates. Tier 3 methods are typically used for estimating non-CO_2 emissions, because CO_2 emission factors do not vary by combustion technology.

Each pathway section below presents 1) a brief description of how inventory and project emissions are calculated for each mitigation activity, and 2) a table of data elements that identifies typical overlap between top-down and bottom-up data elements. These sections were developed based on a synthesis of the *2006 IPCC Guidelines* and mitigation MRV methods listed in *Annex Table 8*. The sections allow users to identify common data elements in both top-down and bottom-up GHG accounting, such as the same or similar activity data points or emission factors. If data points are common across top-down and bottom-up accounting, they may represent an opportunity for further analysis and harmonization in *Step 4*. This section also illustrates how the indicators presented in *Table 2* are used in accounting methods.

Pathway 1. Reduce emissions from fossil fuel combustion for electricity generation

Grid-connected renewable electricity capacity/generation. Projects that increase capacity and generation of zero-carbon renewable energy reduce the amount of fossil fuels consumed for electricity generation (i.e., they reduce the carbon intensity of the electricity grid). The effects of renewable energy generation are inherently captured in fuel combustion for electricity generation in top-down calculations, as the amount of fossil fuel consumed in the energy industries sector is reduced (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

Bottom-up GHG accounting for zero-carbon renewable energy projects also takes into account the quantity of fossil fuels consumed for electricity generation. Because zero-carbon renewable energy projects do not generate emissions, emission reductions for these mitigation projects are often estimated by calculating emissions from fossil fuel combustion that were displaced by the zero-carbon electricity generation. These reductions can be estimated using project- and location-specific information on fuel consumption for electricity generation at existing plants, the quantity of electricity generated by renewable and/or low-carbon sources (offsetting fossil fuel combustion), and electricity emission factors (either marginal or grid emission factors).

On-site (distributed) renewable energy generation. When end users of electricity (e.g., industrial and commercial buildings and residential homes) generate renewable energy on-site, this reduces demand for grid-supplied electricity and the fossil fuels combusted to generate this electricity. These emissions are captured in the inventory through reduced fossil fuel consumption for electricity generation (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

Using a bottom-up methodology, avoided emissions for these mitigation activities correspond to the GHG emissions that would have occurred at a fossil fuel power plant to produce the same amount of electricity as that generated on-site by renewable energy. These reductions can be estimated using project- and location-specific information on fuel consumption for electricity generation at existing plants, the quantity of net electricity generation that is offset by renewable sources used on-site, and electricity emission factors (either marginal or grid emission factors).

Fuel switching. These mitigation activities impact GHG emissions by switching to fuels with a lower carbon content. For example, carbon content per unit of energy is high for coal, while carbon content is lower for natural gas and low-GHG renewable fuels such as biomass. If a carbon-intensive fossil fuel is replaced with a less-carbon-intensive fuel for electricity generation (e.g., switching from coal to natural gas or biomass), this reduces fossil fuel consumption for the high-GHG fuel, increases consumption for the low-GHG fuel, and reduces the overall carbon intensity of the electricity grid. These emissions are inherently captured in the changing fuel quantities reported for electricity generation in top-down calculations (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

Emission reductions from fuel switching are typically estimated as the difference between the GHG emissions that would have occurred from the higher-carbon fuels and the GHG emissions that occurred from electricity generated by the lower-carbon fuels. These reductions can be estimated using project- and location-specific information on fuel consumption for electricity generation at existing plants, the quantity of existing carbon-intensive fuels that would be displaced by less-carbon-intensive fossil fuels to generate the same amount of electricity, facility- and fuel-specific emission factors, the quantity of electricity supplied, electricity emission factors (either marginal or grid emission factors), and upstream GHG emissions from biomass production and transport (if applicable).

Alternative energy sources. In addition to reducing GHG emissions from grid-supplied electricity by reducing electricity demand, these mitigation activities can have secondary impacts on Waste sector emissions if on-site energy is generated through waste management practices. For example, if landfill gas is captured for energy recovery rather than emitted as vented methane, this reduces GHG emissions from the disposal of solid waste (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production, and 4A – Solid Waste Disposal*).

In bottom-up methodologies, avoided emissions are the difference between alternative energy project emissions and baseline emissions (i.e., emissions that occur in the absence of the specified project). Baseline emissions correspond to emissions that would have occurred if the waste material were left to decay and the methane was emitted into the atmosphere. For mitigation activities that recover and use methane for energy generation, project emissions correspond to emissions from the fuel (e.g., waste methane) used by the facility.

Electricity transmission and distribution efficiency. Losses due to transmission and distribution of electricity result in greater generation to meet the same amount of demand. Improved efficiency of transmission and distribution systems reduces the quantity of fossil fuel consumed to meet energy needs, thus reducing GHG emissions from fossil fuel combustion for electricity generation. Reduced losses from electricity transmission and distribution (T&D) are inherently captured in the amount of fuel combustion for electricity generation in top-down calculations (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

Using a bottom-up methodology, emission reductions are typically estimated as the difference in emissions from technical loss that would occur in the existing T&D system and emissions from technical loss that would occur in the T&D technologies employed in the project activity. Technical losses from transmission are calculated based on the amount of the gross electricity supplied at the point of origin and the net electricity received at the point of receipt of the transmission line. Technical losses from distribution transformers are calculated based on manufacturer information and equipment monitoring procedures. Emissions are then calculated as the product of these losses and the GHG emission factor for the system.

Building energy efficiency and demand-side management. Reductions in building energy use reduce electricity demand, which in turn reduces the amount of fossil fuels combusted for electricity generation as reported in the inventory. (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

Mitigation projects that reduce grid electricity use through the use of more efficient end-use equipment or behavior change result in reduced energy use in buildings. Bottom-up emission reductions are estimated as the difference in emissions from electricity use by the existing equipment and emissions from electricity use by the more energy efficient equipment. These reductions can be estimated using building-specific information on energy consumption, equipment (e.g., operating hours, electrical power demand), percentage of technical loss from T&D, electricity emission factors (either marginal or grid emission factors), as well as any emissions from physical leakage of refrigerants from the equipment.

Power plant efficiency. Process improvements in power plants through rehabilitation and/or energy efficiency improve performance, achieving the same electricity generation with less fossil fuel consumption. Emission reductions from improved power plant efficiency are inherently captured in the amount of fuel combustion for electricity generation in top-down calculations. (*IPCC Source Category: 1A1a – Energy Industries: Public Electricity and Heat Production*).

In bottom-up calculations, emission reductions are estimated as the difference between emissions from less-efficient electricity generation at the power plant and emissions from efficient electricity generation at the power plant. Emission reductions can be estimated using information on fuel consumption for electricity generation at the existing plant, facility- and fuel-specific emission factors, the quantity of electricity supplied by the plant, and electricity emission factors (either marginal or grid emission factors).

Table 3 presents primary data elements that are typically collected to estimate GHG emissions from activities that reduce fossil fuel combustion for electricity generation in top-down and/or bottom-up methodologies.

Table 3: Primary Data Elements for Activities that Reduce Emissions from Fossil Fuel Combustion for Electricity Generation

Data Element	Top-Down	Bottom-Up							Metric
		RE	On-Site Generation	Fuel Switching	Alternative Energy	T&D	DSM and Building EE	Power Plant EE	
Activity Data									
Fossil fuel consumption for electricity generation	✓	✓	✓	✓	✓			✓	•
Gross electricity generation		✓		✓		✓		✓	
Delivered electricity						✓			
Renewable energy generation		✓	✓	✓					•
Percent technical loss from T&D system			✓		✓	✓	✓		•
MSW incinerated for energy recovery	✓				✓				•
Waste gas captured for energy generation	✓				✓				•
Wood biomass and biofuel consumption for electricity generation	✓			✓					•
End-use electricity sales			✓		✓		✓		•
Amount of electricity consumed			✓		✓		✓		
Amount of electricity saved							✓		
Emission Factor									
Emission factors for fuels used for electricity generation (country-specific or IPCC default)	✓		✓	✓	✓			✓	
Electric grid or marginal emission factors		✓	✓	✓	✓	✓	✓	✓	•

Note: The "✓" notation indicates data elements captured by either the top-down (inventory) calculations or the bottom-up (project MRV) calculations. Metrics are noted with "•". RE = renewable energy; T&D = transmission and distribution; DSM = demand-side management; EE = energy efficiency.

Pathway 2. Reduce emissions from on-site fossil fuel combustion in the energy industries, residential, commercial, and industrial sectors

On-site (distributed) renewable energy generation and alternative energy sources. Switching from fossil fuels (e.g., diesel) to zero- or low-carbon renewable alternatives to generate energy on-site at industrial and commercial facilities and residential homes reduces GHG emissions from fossil fuel combustion at these sites. In addition, alternative sources of energy such as waste-to-energy and methane gas recovery can provide energy for waste facilities to use on-site and reduce the need for on-site fossil fuel combustion, as well as impact Waste sector emissions (as described in Pathway 1). Similar to Pathway 1, this reduces emissions by reducing the overall quantity of fossil fuels consumed. However, unlike Pathway 1, the emission reductions would occur in the industrial (manufacturing industries and construction), commercial, and residential sectors, rather than at electric power plants that generate electricity for the grid (*IPCC Source Category: 1A2 – Manufacturing Industries and Construction, 1A4 – Other Sectors, and 4A – Solid Waste Disposal*).

Emission reductions for these mitigation projects are estimated as total emissions from fossil fuel combustion for on-site energy generation at a given facility that were displaced by the low- or zero-carbon carbon generation, minus any project-related emissions (e.g., from low-carbon energy sources such as biomass). These reductions can be estimated using project- and location-specific information on fuel consumption for energy generation at the facility, the quantity of energy generation that was offset by renewable and/or low-carbon sources, and fuel-specific emission factors.

Building energy efficiency (on-site combustion) and power plant efficiency. Projects that displace on-site fuel combustion from the use of more efficient equipment or technologies result in reduced on-site energy use. This is captured by reduced end-use sector fuel consumption in top-down calculations (*IPCC Source Category: 1A1b – Energy Industries: Petroleum Refining, 1A1c – Energy Industries: Manufacture of Solid Fuels and Other Energy Industries, 1A2 – Manufacturing Industries and Construction, and 1A4 – Other Sectors*).

Emission reductions are estimated as the difference in emissions from energy use by the existing equipment and emissions from energy use by the more energy efficient equipment. For building energy efficiency, these reductions can be estimated using building-specific information on energy consumption and equipment (e.g., operating hours, occupancy), as well as any emissions from physical leakage of refrigerants from the equipment. For power plants, these reductions can be estimated using information on fuel consumption for energy industry operations and facility- and fuel-specific emission factors.

Table 4 presents primary data elements that are typically collected to estimate GHG emissions from activities that reduce on-site fossil fuel combustion in top-down and/or bottom-up methodologies.

Table 4: Primary Data Elements for Activities that Reduce Emissions from On-Site Fossil Fuel Combustion in the Energy Industries, Residential, Commercial, and Industrial Sectors

Data Element	Top-Down	Bottom-Up On-Site RE and Alternative Energy	Bottom-Up Building and Power Plant EE	Metric
Activity Data				
Fossil fuel consumption in energy industries, residential, commercial, and industrial sectors	✓	✓	✓	•
Renewable energy generation on-site		✓		•
Energy savings			✓	•
Amount of electricity consumed			✓	
MSW incinerated for energy recovery	✓	✓		•
Waste gas captured for energy generation	✓	✓		•
Wood biomass and biofuel consumption for electricity generation	✓	✓		•
Emission Factor				
Emission factors for fuels used for energy generation on-site (country-specific or IPCC default)	✓	✓	✓	

Note: The "✓" notation indicates data elements captured by either the top-down (inventory) calculations or the bottom-up (project MRV) calculations. Metrics are noted with "•". RE = renewable energy; EE = energy efficiency.

Pathway 3. Reduce emissions from fossil fuel combustion in the transport sector

Fuel efficiency and reductions in vehicle distance traveled. Mitigation activities in the transport sector such as fuel efficiency improvements and mode shifting reduce GHG emissions from fossil fuel combustion in vehicles and non-road equipment. Similar to Pathway 1, this reduces emissions by reducing the overall quantity of fossil fuels consumed. However, unlike Pathway 1, emission reductions would occur in the transport sector, rather than at electric power plants that generate electricity for the grid. Top-down calculations rely on the quantity of fuel consumed by fuel type, as well as more technology-specific information such as vehicle types, pollution controls, and distance traveled by mode for non-CO_2 emissions in more advanced methods (*IPCC Source Category: 1A3 – Transport*).

Emission reductions from fuel efficiency improvements, mode shifting, or transportation demand management projects are generally based on factors such as fuel consumption by mode (if available), number of single-occupancy vehicles, difference in fuel efficiency, number of trips by mode, or vehicle distance traveled by mode. Mitigation project activities that encourage walking or biking have zero emissions; emission reductions are determined based on the avoided distance traveled and transportation mode share change.

Fuel switching to alternative fuels. Switching from conventional vehicles to low-carbon or renewable fuel vehicles reduces GHG emissions from fossil fuel combustion in the transport sector. Depending on the fuel type, the GHG effects of these mitigation activities can differ. For example, switching from conventional fuel vehicles (e.g., gasoline or diesel) to biofuel vehicles reduces the carbon intensity of fuels used in transportation due to the lower carbon content of biofuels. Similar to the fuel switching mitigation activity in Pathway 1, the quantity of fuel combusted may remain the same, but emissions are reduced by switching to fuels with a lower carbon content. However, unlike Pathway 1, the emission reductions occur in the transport sector (*IPCC Source Category: 1A3 – Transport*).

For alternative fuel vehicles (e.g., biofuels, CNG), bottom-up project emissions are calculated using information on the quantity of low-carbon fuels used for mobile combustion, reductions in fossil fuel consumption, fuel-specific emission factors, and upstream GHG emissions from fuel production and transport, as applicable (e.g., biofuels).

Fuel switching to electric vehicles. Switching from conventional fuel vehicles to electric vehicles reduces the quantity of fossil fuels consumed for transportation, as well as secondary impacts on electricity emissions. Deployment of electric vehicles increases demand for electricity from the transport sector, which may increase GHG emissions from energy industries if the electricity was generated by fossil fuels. These GHG effects are captured in the energy industries sector, rather than the transport sector (*IPCC Source Category: 1A3 – Transport, and 1A1a – Energy Industries: Public Electricity and Heat Production*).

For projects that involve electric and hybrid vehicles, baseline emissions are those that would occur from the operation of conventional fuel vehicles to provide the same transportation service as the specified project. Project emissions are based on emissions from electricity generation used for electric vehicles associated with their operation. Emission reductions are estimated as the difference between project and baseline emissions, and can be calculated using information on fuel consumption, distance traveled by vehicle type, number of operational project vehicles, electricity consumed for charging project vehicles, and fuel- and technology-specific emission factors.

Table 5 presents primary data elements that are typically collected to estimate GHG emissions from activities that reduce fossil fuel combustion in the transport sector in top-down and/or bottom-up methodologies.

Table 5: Primary Data Elements for Activities that Reduce Emissions from Fossil Fuel Combustion in the Transport Sector

Data Element	Top-Down	Bottom-Up Fuel Efficiency and VDT	Bottom-Up Alternative Fuels	Bottom-Up Electric Vehicles	Metric
Activity Data					
Fossil fuel consumption in vehicles by fuel type	✓	✓	✓	✓	•
Fossil fuel consumption for electricity generation				✓	•
Alternative fuel consumption in vehicles	✓		✓		•
Number of passengers/freight trips		✓			
Vehicle fuel efficiency (average)		✓			•
Vehicle distance traveled by vehicle and fuel type	✓*	✓			•
Mode share		✓			
Electricity sales to the transport sector				✓	•
Emission Factor					
Emission factors for fuels and vehicle types used for transportation (country-specific or IPCC default)	✓	✓	✓		
Emission factors for fuels used for electricity generation (country-specific or IPCC default)	✓			✓	

Note: The "✓" notation indicates data elements captured by either the top-down (inventory) calculations or the bottom-up (project MRV) calculations. Metrics are noted with "•". VDT = vehicle distance traveled.

* Advanced methods for non-CO_2 emissions.

Once accounting information has been compiled using the data sources above for each activity, users can determine whether the national inventory captures mitigation GHG impacts according to the guidance in *Step 4*.[6]

After completing *Step 3*, users have:

- Identified the primary metrics for each GHG pathway to measure the GHG impacts of the selected mitigation activity.
- Assessed and compared the bottom-up and top-down GHG accounting methods and data elements by pathway.

[6] For more detailed instructions on comparing data elements, see the General Framework Guide. Available online at: https://www.climatelinks.org/resources/rali-ghg-mrv-harmonization-framework

Step 4: Identify Opportunities to Harmonize Accounting

There are several common opportunities for harmonization that may arise when comparing bottom-up and top-down accounting in the Energy sector. These include opportunities to harmonize data elements used in the two accounting approaches, as well as improving overall inventory and mitigation activity processes.

Step 4: A harmonization opportunity may include developing using country- or technology-specific emission factors that consider changes in fuel mix over time.

In *Step 4*, users will:

- Determine whether the national inventory captures mitigation GHG impacts.
- Identify opportunities to harmonize top-down and bottom-up accounting methods.
- Review harmonization opportunities and examples in the Energy sector.

4.1 Determine if National Inventory Captures Mitigation GHG Impacts

Based on the assessment of top-down GHG accounting in *Step 3*, determine whether the national inventory **does or does not** currently capture the GHG impacts of the mitigation activity: for example, by incorporating activity data from mitigation projects or adjusting emission factors to incorporate the use of mitigation technologies. Understanding how the current inventory captures mitigation GHG impacts will help uncover areas where harmonization already exists or can be improved.

For energy mitigation activities, many of the GHG effects are likely to be inherently reflected in inventory calculations. For example, switching from fossil fuels to zero-carbon renewable energy reduces the amount of fossil fuels consumed, as captured by national energy balances, and results in a decrease in combustion emissions. This relies on having a complete national energy balance and accurate data on fuel consumption by fuel type. While these impacts may be inherently reflected in national inventories, the Framework can help focus efforts on strengthening the methodologies and data sources used in both bottom-up and top-down GHG accounting to be able to understand and adequately quantify avoided emissions from energy mitigation activities.

Users should analyze the information collected in *Step 3* to determine whether activity data or emission factors currently used in the inventory can capture changing trends due to mitigation activities. Questions to consider include:

- **Are mitigation project-level data used?**

  National inventory estimates of fossil fuel combustion emissions rely on self-reported national energy statistics, survey data, or fuel supplier information. To the extent possible, bottom-up mitigation project-level data can be used to validate and improve the data used in national inventories. For example, bottom-up data from mandatory reporting programs that require individual facilities to track their direct emissions can be used to validate and/or supplement emissions estimated using national energy statistics or other data sources.

- **Does the inventory capture changing trends?**

  If the inventory methodology does not capture reductions in emissions from mitigation activities, this presents an opportunity to harmonize top-down and bottom-up accounting. For example, if an inventory uses default emission factors by fuel type from IPCC to estimate emissions from fossil fuel combustion, the inventory may not capture changes resulting from mitigation activities as it would with country-specific factors that are informed by project-specific data on the technology and quality of fuels that are combusted. Here, the adoption of Tier 2 or 3 methodologies can enable the inventory to reflect these activities.

- **Are data collected frequently enough to capture changing trends?**

  Increasing the frequency of data collection can be an effective strategy for capturing GHG effects from mitigation activities. For example, if fossil fuel consumption data are collected on a monthly or annual basis, but data on biomass used to generate electricity are collected every five years, the inventory will not adequately capture changes in the carbon intensity of energy generation over time from low-carbon renewable activities. Increasing the frequency of low-carbon renewable fuel consumption data collection allows the inventory to capture GHG effects accurately and to track the impact of mitigation activities on emissions.

4.2 Identify Harmonization Opportunities

In this part of *Step 4*, users should identify harmonization opportunities by comparing bottom-up and top-down data elements. Documenting, prioritizing, and implementing identified opportunities will be covered in *Step 5* and *Step 6*.

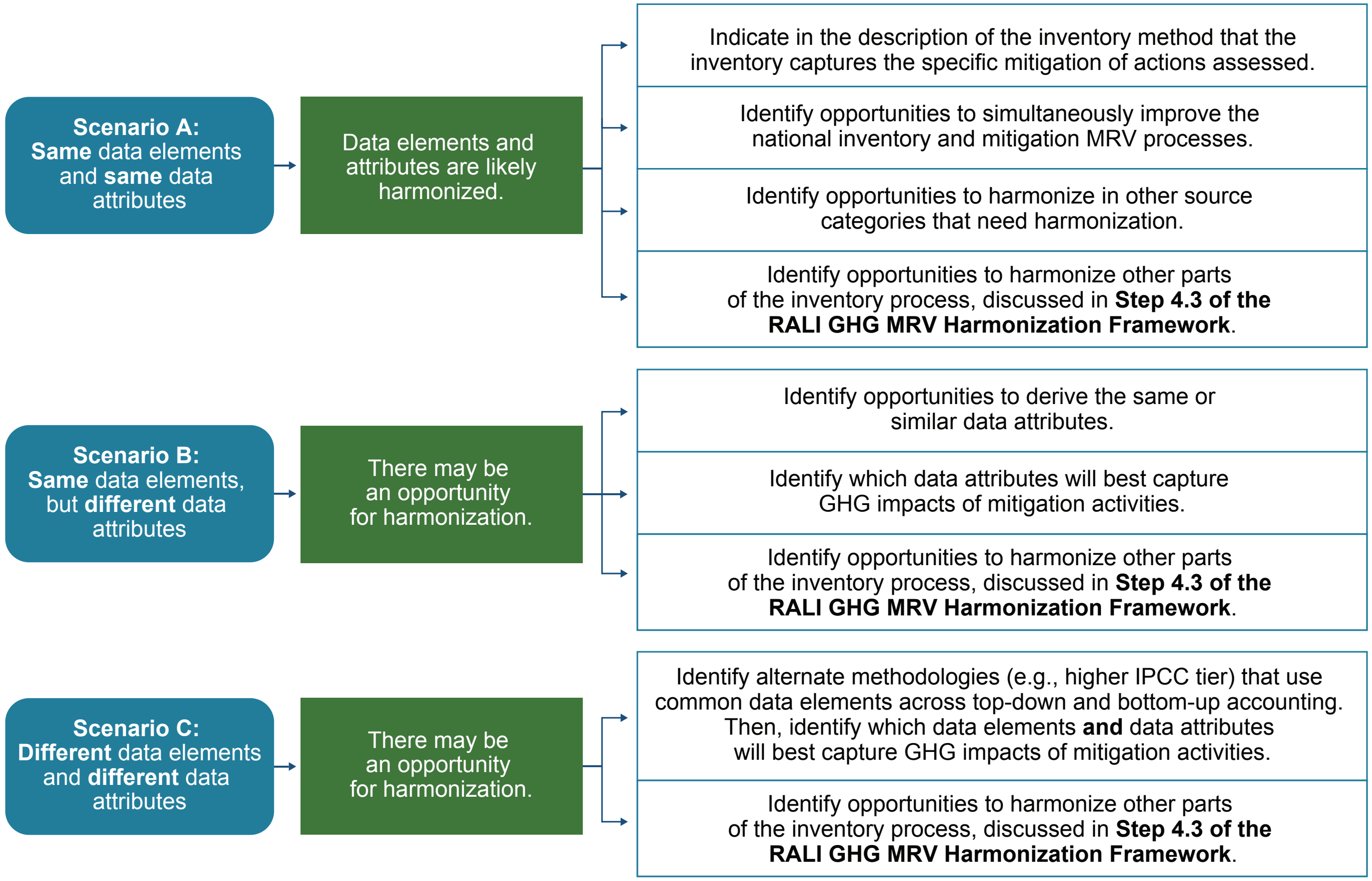
In this discussion, "**data element**" refers to any variable that is used to calculate emissions in national inventory or mitigation MRV methods. A "**data attribute**" is a characteristic of the data element. Harmonization opportunities might lie within changing one or more of these data attributes. *Table 6* provides the definition and examples of data elements and data attributes.

Table 6: Data Element and Data Attribute Definitions and Examples

	Data Element	Data Attribute
Definition	Any variable that is used to calculate emissions	Characteristic of the data element
Examples	• Fossil fuel consumption • Grid emission factors • Renewable energy generation • End-use electricity sales • Wood biomass and biofuel consumption • MSW incinerated for energy recovery • Percent technical loss from T&D • Building energy use intensity	• Source of the data • Frequency of data collection or publication • Unit of measurement • Level of data granularity (e.g., project level, regional, national) • Level of uncertainty (qualitative and/or quantitative) • IPCC methodology tier (if applicable) • Key assumptions • Reporting status • Data quality

Figure 8 shows three likely scenarios that may arise as bottom-up and top-down data elements are compared, and how to identify harmonization opportunities within this scenario. This Framework can be used to understand common harmonization opportunities in the Energy sector.

Figure 8: Harmonization Opportunity Flow Chart



For more detailed instructions on identifying opportunities to harmonize other components of the inventory process, such as institutional arrangements, data documentation and reporting, uncertainty analyses and discussion, and improvement planning, see the General Framework Guide.[7]

[7] See the RALI GHG MRV Harmonization Framework: A General Framework Guide. Available online at: https://www.climatelinks.org/resources/rali-ghg-mrv-harmonization-framework

4.3 Review Potential Harmonization Actions

The actions that an inventory team can take to harmonize accounting methods vary by available resources, mitigation activity, inventory source category, and other factors. Opportunities for harmonization uncovered in *Steps 1* through *4* could include low- or no-cost options, such as documentation of findings, or could require extensive investment in new projects; the choice of which actions to implement depends on the relative priority of each improvement on the inventory and trends. Some examples of harmonization actions include:

- Define new data sources and incorporate new institutional arrangements
- Create new data templates for mitigation activity implementers
- Align schedules of inventory and MRV data collection
- Increase the frequency of data collection
- Move to a higher IPCC tier of the inventory methodology
- Develop more specific emission factors (e.g., country- or project-specific)
- Splice subnational data into national data
- Form new institutional arrangements or strengthen current ones
- Update or create new reporting procedures
- Document qualitative or quantitative uncertainties uncovered through the harmonization process
- Document harmonization opportunities as planned improvements to the inventory
- Update the Inventory Improvement Plan to include harmonization opportunities

Below are examples of harmonization opportunities for Scenarios A, B, and C for energy mitigation activities that involve switching from a GHG-intensive energy source (e.g., coal) to a less GHG-intensive renewable energy sources (e.g., biomass) for electricity generation to reduce emissions from fossil fuel combustion and reduce the carbon intensity of the national energy supply. Fossil fuel consumption and wood biomass and biofuel consumption are metrics for the fuel switching mitigation activity, as explained in the Pathway 1 section of *Step 3*.

Scenario A: Same data elements and same data attributes

Fuel consumption is used for both the top-down and bottom-up methodology to estimate emissions from fossil fuel combustion and biomass combustion at electric power facilities (same data element). Fuel consumption data are updated annually based on national statistics that compile individual facility-reported fuel use data (same data attribute).

Top-Down Methodology	Bottom-Up Methodology	Type of Alignment Issue
Fuel consumption data are updated annually from national energy statistics	Fuel consumption data for an individual facility are collected and reported annually to national energy statistics	No alignment issue identified

Harmonization opportunity – Likely harmonized: Fuel consumption values in the top-down and bottom-up methodologies have the same data source and update frequency. As a result, the mitigation activity is likely captured in the national inventory, so it is likely that no alignment issue exists. In this case, national inventory compilers and project mitigation stakeholders can seek to simultaneously improve the fuel consumption value by coordinating to improve estimates or reduce uncertainty, or devote limited resources to other data elements that are not in alignment.

Scenario B: Same data elements, but different data attributes

Fuel consumption is used for both the top-down and bottom-up methodology (same data element). Fuel consumption data are updated annually based on national statistics in the top-down methodology, but fuel consumption data at the individual facility project area are estimated based on fuel costs at the individual facility (different data attribute). The facility does not report fuel consumption or project data to national statistics.

Top-Down Methodology	Bottom-Up Methodology	Type of Alignment Issue
Fuel consumption data are updated annually from national energy statistics	Fuel consumption data for an individual facility are collected annually but are not reported to national energy statistics	Data source

Harmonization opportunity – Create new reporting structure: The opportunities to harmonize are to initiate bottom-up reporting of the specific facilities included in this mitigation activity to national energy statistics.

Scenario C: Different data elements and different data attributes

A Tier 1 methodology is used to estimate emissions from fossil fuel combustion in energy industries in the top-down methodology using fuel consumption activity data from national energy statistics and default Tier 1 emission factors by fuel type. The bottom-up methodology uses annual fuel mix data to estimate a local grid electricity emission factor in the specified project area and estimates emissions based on the amount of electricity generated (different data elements). While the data source for the top-down methodology is IPCC (2006), the bottom-up mitigation activity uses project-specific emission factors that reflect country-specific circumstances (different data attributes). The facility does not report fuel mix information to national statistics.

Top-Down Methodology	Bottom-Up Methodology	Type of Alignment Issue
Fuel consumption data are updated annually from national energy statistics; default Tier 1 emission factors by fuel type from IPCC (2006)	Fuel mix data are collected and used to develop grid emission factors for the specified project area but are not reported to national energy statistics	Data Element, Frequency of Collection, and Data Source

Harmonization opportunity – Move to a higher IPCC tier of the inventory methodology: The opportunity to harmonize is for the national inventory to move from Tier 1 to a higher IPCC tier by initiating bottom-up reporting of the specific facilities included in this mitigation activity to national energy statistics and transitioning from using an IPCC default emission factor to country- or technology-specific emission factors that take into account changes in fuel mix over time.

Review of Steps 1 through 4 of the Framework: Applying the Framework to a Sample Activity
Switching to a less-carbon-intensive fossil fuel for grid electricity generation

Below is an example of how to apply the Harmonization Framework. In this example, Country A switches from coal to natural gas for electricity generation at several power plants that supply electricity to the grid.

Step 1:
This activity falls under the “fuel switching” mitigation activity category. Switching from a higher-carbon energy source (e.g., coal) to a less GHG-intensive energy source (e.g., natural gas) for electricity generation reduces the carbon intensity of the electricity being generated and reduces emissions from fossil fuel combustion.

Step 2:
This activity impacts the national inventory through Pathway 1: Reduce emissions from fossil fuel combustion for electricity generation. This is mapped to *IPCC Source Category 1A1a: Public Electricity and Heat Production* in Country A’s national inventory.

Step 3:
Country A uses the following top-down and bottom-up methodologies to estimate emissions for this activity:

Top-Down Methodology	Bottom-Up Methodology
Emissions from electricity generation are estimated by multiplying fuel consumption data from national energy statistics by IPCC default Tier 1 emission factors by fuel type. National energy statistics include individual facility-reported fuel use data.	Emission reductions are estimated as the difference between GHGs that would be emitted from coal-fired power plants and GHGs emitted from electricity generated in natural-gas-fired power plants. Reductions are estimated using facility- and fuel-specific consumption data and emission factors.

Step 4:
Fossil fuel consumption and emission factors for electricity generation are the primary data elements used for both the top-down and bottom-up methodologies (**same data elements**). Fuel consumption data used in the national inventory are derived from information reported by individual facilities in the project area (**same data attribute**). However, while the national inventory uses IPCC default emission factors, emission reduction calculations for the mitigation activity use facility-specific information (**different data attribute**).

As shown in Scenario B in *Figure 8*, this presents a harmonization opportunity for Country A. The opportunity to harmonize is for the national inventory to move from Tier 1 to a higher IPCC tier by transitioning from using an IPCC default emission factor to country-specific emission factors that better take into account the actual carbon content of the fuels. Additionally, facility-specific GHG emissions and reductions from the bottom-up calculations can be incorporated into the national inventory. Measured emissions or measured plant-specific fuel quality (e.g., carbon content of fuel) improve the accuracy of inventory calculations compared with national estimates based on default or country-specific emission factors for the reporting facilities.

After completing *Step 4*, users have:

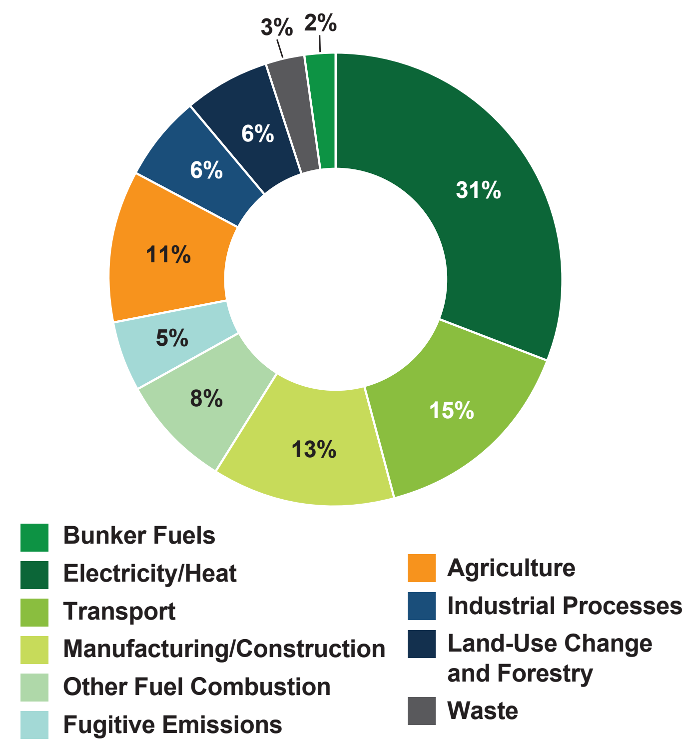
- Determined whether the national inventory captures mitigation GHG impacts.
- Identified opportunities to harmonize top-down and bottom-up accounting methods.
- Reviewed harmonization opportunities and examples in the Energy sector.

Step 5: Prioritize Improvements to GHG Accounting

Several factors will influence which recommendations identified in *Step 4* will be adopted by countries. Countries will need to define which criteria to consider when prioritizing improvements, and then prioritize recommendations to maximize the impact on GHG accounting transparency, accuracy, completeness, comparability, and consistency. Any inventory improvements should be prioritized within the context of country emissions, emission reduction ambitions and targets, co-benefits of inventory or data improvements, and more. For example, one factor to consider is whether the potential improvement significantly impacts a key category in the inventory, which would imply that the improvement is a higher priority. Users should also consider Energy harmonization actions in the context of other sectors.

The Energy sector accounts for over 70 percent of global emissions (see *Figure 9*) (WRI CAIT 2017). The largest source of global emissions is the generation of heat and electricity, followed by fuel combustion for transport, and fuel combustion for manufacturing/construction industries. While the specific breakdown of emissions within each country varies, most countries will have several key categories within the Energy sector, with the generation of electricity and heat commonly being the largest source. Therefore, improvements to this category will have a relatively large impact on harmonization.

Figure 9: Global Emissions (2014)



In *Step 5,* users will:

- Develop a framework for prioritizing impacts by defining criteria to consider when prioritizing improvements.
- Prioritize improvements to maximize the impact on GHG accounting transparency, accuracy, completeness, comparability, and consistency.

5.1 Develop Criteria for Prioritizing Improvements

Users should define country-specific evaluation criteria to prioritize harmonization improvements. These criteria will be affected by existing national priorities. The impact of harmonization improvements in specific sectors can then be assessed based on their relative importance to criteria such as:

- Status as a key category
- Mitigation potential
- Emission trends
- Uncertainty levels, and
- Contribution to mitigation commitments.[8]

These criteria can also complement other evaluation criteria, such as existing GHG accounting approaches, institutional resources, overall institutional dynamics, and alignment with other development goals.

To prioritize harmonization opportunities, identify which criteria to use, their relative importance, and their target outcome (e.g., increase mitigation potential, reduce uncertainty levels). This selection process can be performed by any of the key stakeholders considering harmonization improvement priorities. This selection process can also be used to prioritize harmonization opportunities for multiple mitigation activities simultaneously, including non-Energy sector mitigation projects that are occurring.

5.2 Sensitivity Analysis

Countries may also choose to conduct a quantitative analysis to understand the relative impacts of harmonization improvements on their national emissions, in order to identify priority improvements. A sensitivity analysis provides a quantifiable process for evaluating data elements. Specifically, a sensitivity analysis helps determine the relative importance of input variables (i.e., variables used in a GHG inventory methodology) and how they impact the output result (i.e., GHG emissions reported in the inventory). The outcome of conducting a sensitivity analysis is a ranking of those input variables in order of the size of their relative impact on the emission calculation result. If a specific improvement would significantly impact one of these elements, users should consider prioritizing that action over one that has a less significant impact.

[8] For example, if a country commits to reducing fugitive emissions from energy activities as the primary means by which they are to meet their NDC target, harmonization activities in this area may be a higher priority.

Method

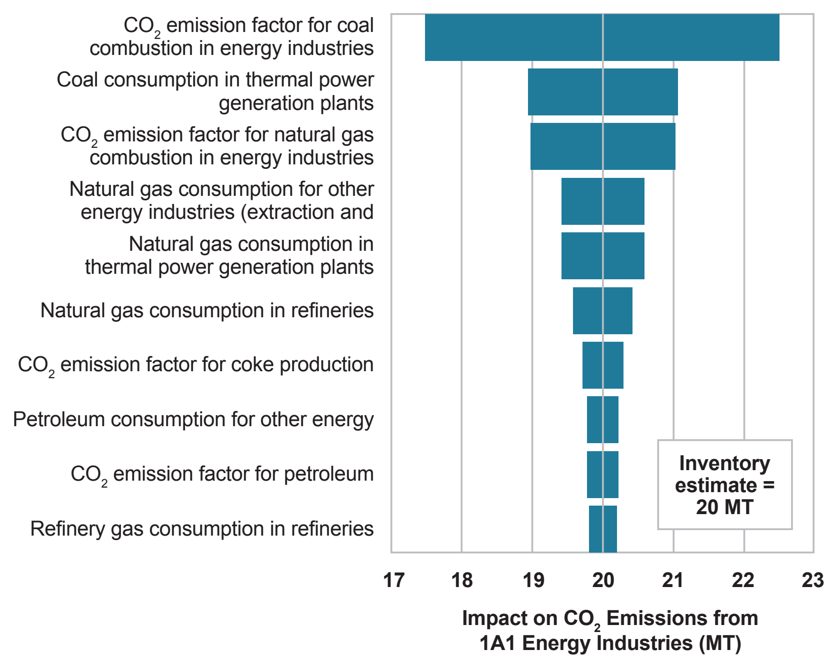
The first step in a sensitivity analysis is to identify the output variable on which the analysis will be run (e.g., total emissions for an inventory sector or source category). Next, an analysis of the emission calculation must be completed to establish the most basic input variables to the equation. For an idealized "Activity Data [A] x Emission Factor [B] = Emissions [C]" equation, these are the As and Bs. In more complex calculations, the As and Bs may break down into many dozens of different input variables.

Once a list of inputs has been defined the sensitivity analysis can occur. One by one, each of the input variables is varied by a specified percentage (most commonly +/-10%) while recording how the emission estimate changes as a result. When completed, the analysis generates a list of each of the input variables, the range by which they were varied, and the resulting change to the emission estimate. The list is then sorted from high to low based on the impact to the overall emission estimate, with the input variables at the top of the list having the largest impact on results. The top several input variables should be prioritized as they have the largest potential impact on the emission estimate. In prioritizing harmonization improvements to data sources, uncertainty calculations, and inventory methods, these key inputs should rise to the top.

Example Sensitivity Analysis for the Energy Sector

Figure 10 shows an example of quantitative sensitivity analysis results for CO_2 emissions from *IPCC Source Category: 1A1 – Energy Industries* for an example national inventory. The analysis ranks the most important activity data and emission factor inputs based on their relative impact on total CO_2 emissions for this source category. This information allows users to see which variables have the largest impact on their inventory results, and therefore which should be prioritized for improvements—both in accuracy and in targeting mitigation activities. In the example shown in *Figure 10*, varying each input by the same percentage (+/- 10%) demonstrates that changes in the CO_2 emission factor for coal—e.g., the carbon content—has the largest impact on emissions from energy industries.

Figure 10: Impact on CO_2 emissions from Energy Industries by Data Element (metric tons [MT])



The carbon content of coal depends on the quality of fuel combusted at an electric power plant (provided by the fuel supplier). Therefore, strategies that gather more plant-specific information about fuels used for electricity generation will inform a more accurate estimate of current emissions from coal combustion in energy industries. For example, bottom-up MRV that involves measured plant-specific carbon contents could be used to improve top-down emission estimates that are based on default or country-specific emission factors for the reporting facilities and could also ensure that improvements in the quality of coal are captured.

Since available country-specific emission factors might differ for different fuels, combustion technologies, or even individual plants, activity data could be further disaggregated to properly reflect such disaggregated sources. If these country-specific emission factors indeed are derived from detailed data on carbon contents in different batches of fuels used in facilities or from more detailed information on the combustion technologies applied in the country, the uncertainties of the estimate should decrease and the trends over time can be better estimated.

After completing *Step 5*, users have:

- Developed a framework for prioritizing impacts by defining criteria to consider when prioritizing improvements.
- Prioritized improvements to maximize the impact on GHG accounting transparency, accuracy, completeness, comparability, and consistency.

Step 6: Implement and Harmonize

The implementation of harmonization opportunities in the Energy sector may take many forms and may require other stakeholders than were engaged in *Steps 1* through *5*. This process will ultimately be country-specific, and will require implementers to:

- Determine resources, roles, and responsibilities for implementing improvements,
- Work with national inventory compilers, source category leads, and other inventory stakeholders throughout the inventory development process to incorporate the identified priority harmonization opportunities in a future national inventory cycle or in the Inventory Improvement Plan; and
- Create or modify existing mitigation activity MRV requirements to better align mitigation reporting with national inventories.

In *Step 6*, users will:

- Engage stakeholders and determine resources, roles, and responsibilities for implementing improvements.
- Implement prioritized harmonization improvements.

As shown in *Figure 11*, improvements can occur across the inventory and mitigation MRV development and implementation process.

After harmonization opportunities have been identified as a result of this process, inventory teams will have additional information that can be used to improve the transparency of their inventory. A low-cost option to apply the findings of the harmonization exercise is to document the findings in describing the methodology, data sources, uncertainty, or planned improvements for the source categories examined.

Step 6 is not unique to the Energy sector, but it is essential to the success of the Harmonization Framework. As with other sectors, developing a sustainable approach to implement the harmonization opportunities in previous steps can allow stakeholders to continuously enhance the transparency of GHG accounting between national GHG inventories and mitigation accounting.

After completing *Step 6*, users have:

- Engaged stakeholders and determined resources, roles, and responsibilities for implementing improvements.
- Implemented prioritized harmonization improvements.

Figure 11: Potential Harmonization Improvements across Inventory Processes

Establish Institutional Arrangements

- Develop and strengthen institutional arrangements with mitigation project implementers
- Develop MOUs (memorandum of understanding) to improve inventory data collection

Develop Methods and Collect Data

- Work with future MRV teams to ensure MRV methods and data collection align with inventory needs
- Refine inventory methods and data sources to reflect more country-specific data in collaboration with project implementers and researchers

Develop Estimates and Conduct Analyses

- Incorporate mitigation project impacts in uncertainty discussions and analyses

Report Results

- Document how mitigation activities impact inventory estimates and uncertainty
- Discuss data gaps where mitigation impacts may not be captured

Plan Improvements

- Include and prioritize harmonization activities in the Inventory Improvement Plan, especially in key categories

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Annex

Table 7: Top-Down Documentation and Associated Data Elements for Energy Mitigation Activities

Documentation	Description	Data Element
Consumption end-use surveys	Surveys conducted to collect fuel consumption and electricity use by specific end users (e.g., residential, commercial, manufacturing and constructions, etc.)	◦ Fossil fuel consumption ◦ Wood biomass and biofuel consumption ◦ Building energy use intensity ◦ End-use electricity sales
Electric power company and/or generator reports	Capacity, generation, sales, revenue, and customer data for all electric power companies and generators in the country	◦ Renewable energy generation capacity ◦ Carbon intensity of electric grid ◦ Percentage of technical loss from T&D system
Project evaluations for renewable or alternative energy projects	Capacity and generation data for renewable or alternative energy projects	◦ Renewable energy generation capacity ◦ MSW incinerated for energy recovery ◦ Waste gas captured for energy generation
National highway/road statistics reports	Statistical information drivers, fuel use, vehicle types, distance, and travel	◦ VDT by vehicle and fuel type ◦ Average vehicle fuel efficiency ◦ Alternative fuel consumption (vehicles)

Table 8: Bottom-Up Standards and Organizations Providing Emission Reduction and MRV Guidance

Organization	Specific Standards for Energy Projects[10]	Applicable Mitigation Activities
Electricity Generation		
American Carbon Registry	Methodology for grid-connected electricity generation from renewable sources	◦ Utility-scale renewable energy installation
Verified Carbon Standard	VM0002 New cogeneration facilities supplying less carbon intensive electricity to grid and/or hot water to one or more grid customers, v1.0	◦ Cogeneration facility
Clean Development Mechanism	ACM0002 Grid-connected electricity generation from renewable sources, Version 19.0	◦ Utility-scale renewable energy installation

[9] The Clean Development Mechanism provides a breadth of bottom-up MRV methodologies that can be used. The following table provides a sample of these methodologies. Additional methodologies can be found in UNFCCC (2017). *CDM Methodology Booklet, 9th edition*. Available at: https://cdm.unfccc.int/methodologies/documentation/1803/CDM-Methodology-Booklet_fullversion_04.pdf.

Organization	Specific Standards for Energy Projects[10]	Applicable Mitigation Activities
Electricity Generation *(continued)*		
Clean Development Mechanism	AM0103 Renewable energy power generation in isolated grids, Version 3.0	Small-scale renewable energy installation
Clean Development Mechanism	AMS-I.A. Electricity generation by the user, Version 16.0	On-site renewable energy generation
Clean Development Mechanism	ACM0011 Fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation, Version 13.0	Switching from coal to gas at an existing power plant
Clean Development Mechanism	AMS-III.B. Switching fossil fuels, Version 18.0	Switching fossil fuels for residential, commercial, industrial, or institutional electricity
Clean Development Mechanism	ACM0022 Alternative waste treatment processes, Version 2.0	Waste treatment for energy use
Clean Development Mechanism	AMS-III.G. Landfill methane recovery, Version 9.0	Methane gas capture
Clean Development Mechanism	ACM0018 Electricity generation from biomass residues in power-only plants, Version 4.0	Biomass fuel use
Clean Development Mechanism	AM0023 Leak detection and repair in gas production, processing, transmission, storage and distribution systems and in refinery facilities, Version 4.0.0	Reduced methane leakages
Clean Development Mechanism	AM0009 Recovery and utilization of gas from oil fields that would otherwise be flared or vented, Version 7.0	Reduced methane flaring
Energy Efficiency		
Verified Carbon Standard	VM0008 Weatherization of single family and multi-family buildings, Version 1.1	Building envelope efficiency
Clean Development Mechanism	AM0120 Energy-efficient refrigerators and air-conditioners, Version 1.0	Appliance efficiency
Clean Development Mechanism	AM0048 New cogeneration project activities supplying electricity and heat to multiple customers, Version 5.0	Energy efficiency from cogeneration for electricity and heat
Clean Development Mechanism	AM0091 Energy efficiency technologies and fuel switching in new and existing buildings, Version 3.0	Building envelope efficiency Appliance efficiency
Clean Development Mechanism	AM0061 Methodology for rehabilitation and/or energy efficiency improvement in existing power plants, Version 2.1	Electricity generation efficiency
Clean Development Mechanism	AM0067 Methodology for installation of energy efficient transformers in a power distribution grid, Version 2.0	Electricity transmission system efficiency
Clean Development Mechanism	AM0046 Distribution of efficient light bulbs to households, Version 2.0	Lighting efficiency

Organization	Specific Standards for Energy Projects[10]	Applicable Mitigation Activities
Transport		
American Carbon Registry	Truck stop electrification	Freight electrification
Verified Carbon Standard	VM0019 Fuel switch from gasoline to ethanol in flex-fuel vehicle fleets, v1.0	Vehicle fuel switching
Verified Carbon Standard	VM0038 Methodology for electric vehicle charging systems, Version 1.0	Vehicle fuel switching
Verified Carbon Standard	VM0028 Methodology for carpooling, Version 1.0	Transportation mode shift from single-occupancy vehicles
Clean Development Mechanism	AMS-III.AA. Transportation energy efficiency activities using retrofit technologies, Version 1.0	Vehicle fuel efficiency
Clean Development Mechanism	AMS-III.BC. Emission reductions through improved efficiency of vehicle fleets, Version 2.0	Vehicle fuel efficiency
Clean Development Mechanism	AMS-III.C. Emission reductions by electric and hybrid vehicles, Version 15.0	Vehicle fuel switching
Clean Development Mechanism	AMS-III.AY. Introduction of LNG buses to existing and new bus routes, Version 1.0	Vehicle fuel switching for bus systems
Clean Development Mechanism	AM0031 Bus rapid transit projects, Version 6.0	Mode shift to bus rapid transit
Clean Development Mechanism	AM0101 High speed passenger rail system, Version 2.0	Mode shift to rail based transit
Clean Development Mechanism	ACM0016 Mass Rapid Transit Projects, Version 4.0	Mode shift to rail or bus transit

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