Policy and Action Standard

Commercial and Residential Buildings Sector Guidance

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Introduction

This document provides sector-specific guidance to help users implement the GHG Protocol *Policy and Action Standard* in the buildings sector which includes both commercial and residential buildings. GHG emissions from buildings primarily arise from their consumption of fossil-fuel based energy, both through the direct use of fossil fuels and through the use of electricity which has been generated from fossil fuels. GHG emissions are also generated during the production of construction materials and running of appliances, in particular insulation and refrigeration materials as well as cooling systems. Energy is primarily consumed during the following activities: manufacturing of building materials, transport of these materials from production plants to building sites, construction of the building, operation of the building, and demolition of the building (and recycling of their parts, where this occurs).

Users should follow the requirements and guidance provided in the *Policy and Action Standard* when using this document. The chapters in this document correspond to the chapters in the *Policy and Action Standard*. This document refers to Chapters 5–11 of the *Policy and Action Standard* to provide specific guidance for the buildings sector. The other chapters have not been included as they are not sector-specific, and can be applied to the buildings sector without additional guidance. Chapters 1–4 of the *Policy and Action Standard* introduce the standard, discuss objectives and principles, and provide an overview of steps, concepts, and requirements. Chapters 12–14 of the *Policy and Action Standard* address uncertainty, verification, and reporting. The table, figure, and box numbers in this document correspond to the table, figure, and box numbers in the standard.

To illustrate the various steps in the standard, this guidance document uses a running example of a hypothetical building code for energy efficiency.

We welcome any feedback on this document. Please email your suggestions and comments to David Rich at drich@wri.org.

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Chapter 5: Defining the policy or action

In this chapter, users are required to clearly define the policy or action that will be assessed, decide whether to assess an individual policy or action or a package of related policies or actions, and choose whether to carry out an ex-ante or ex-post assessment.

5.1 Select the policy or action to be assessed

Table 5.1 provides a non-exhaustive list of examples of policies and actions in the sector for which this guidance document will be useful by policy/action type.

Table 5.1 Examples of policies/actions in the sector by policy/action type

Type of policy or action	Examples
Regulations and standards	Building codes Appliance and equipment performance standards Construction material standards Efficiency standards for HFCs/fluorinated gases (F-gases) used for refrigeration, cooling, insulation, fire-retardant and sound-insulation
Taxes and charges	Carbon tax Public goods charge Energy efficiency penalty
Subsidies and incentives	Energy efficiency tax incentives Renewable rebate
Tradable permits	Energy-efficiency obligations and tradable energy-efficiency certificates
Voluntary agreements	Product and equipment efficiency standards/labeling Sustainable building or energy efficiency standards Sustainability disclosure Inhabitant behavior change incentives
Information instruments	Appliance and equipment labeling Smart metering Benchmarking programs Building energy management systems program Audit programs
Research and development (R&D)	Research grants for technology, building standards, and materials
Public procurement policies	Efficient products and equipment procurement Sustainable or energy efficiency standards for construction and repair
Infrastructure programs	Electrical grid/energy supply policies and improvements Smart grid Cogeneration/ tri-generation programs
Financing and investment	Energy performance contracting Utility rebates Preferential loans

5.2 Clearly define the policy or action to be assessed

A key step in Chapter 5 is to clearly define the policy or action. Chapter 5 in the standard provides a checklist of information users should report. Table 5.2 provides an example of providing the information in the checklist using a hypothetical Building Code for Energy Efficiency. This example will be used throughout the guidance document to illustrate the individual steps of the standard.

Table 5.2 Checklist of information to describe the Building Code policy

Information	Example
The title of the policy or action	Energy Efficient Building Code
Type of policy or action	Regulation
Description of the specific interventions included in the policy or action	The code includes two parts: 1. Energy use intensity (EUI) standards (primary energy) for new buildings differentiated by types of buildings: Residential housing[1]: 80 kWh/m^2 Commercial buildings: 150 kWh/m^2 2. Minimum performance standards for the building envelope, insulation, windows, etc. to meet overall EUI standard.[2] The code will be revised periodically to reduce the energy use intensity of new buildings over time based on long term targets.
The status of the policy or action	Enacted and in force
Date of implementation	Came into force on 1/1/2013
Date of completion (if applicable)	Ongoing
Implementing entity or entities	Provincial government
Objective(s) of the policy or action	Reduction of energy consumption in buildings
Geographical coverage	Sub-national
Primary sectors, subsectors, and emission sources or sinks targeted	Emissions associated with electricity, steam, hot water, and fossil fuels used in buildings for lighting, heating, cooling
Greenhouse gases targeted	CO_2, CH_4, N_2O
Other related policies or actions	*Renewable energy standards and incentives* There are two relevant policies related to renewable energy in buildings: • Mandatory share of 30% of renewable energy for new public buildings • A grant/ loan incentive scheme for converting to wood pellet heating systems and for installation of solar thermal units *Water conservation* The ministry for infrastructure is running regular information campaigns that encourage water conservation in households. The campaigns include TV advertisements, information brochures, training material for schools and a website. *Energy taxes* Energy taxes on fossil fuels, especially oil for central heating systems, have been increased over the past years and are planned to further increase.

[1] For simplification, this example assumes only one type of building. Building codes are usually specified in much more detail, which should be provided for example in an annex.
[2] Details for the set of standards should be provided in annex tables. For simplification they are not included in this example.

	Compliance enforcement Inspection procedures are in place to ensure standards are in fact implemented. For incentive schemes a verification process is in place that ensures that equipment is installed as approved.
Optional information	
Key performance indicators	Energy Use Intensity (EUI) achieved for different types of buildings Number of permits issued per type of building Number of rejections per type of building Number of inspections carried out per type of building Number of negative inspection results per type of building
Intended level of mitigation to be achieved and/or target level of other indicators	New and substantially altered buildings have lower energy use than they would under business as usual.
Intended or target level of mitigation to be achieved- remove	25% reduction in energy use emissions as compared to current standards.
Title of establishing legislation, regulations, or other founding documents	Energy Efficiency Building Code
Monitoring, reporting, and verification (MRV) procedures	Monitoring of fuel consumption in buildings to be done by maintaining a stock balance of fuel opening balance, purchase, consumption and closing balance. Data to be cross-checked with fuel purchase records. Calibration of measuring instruments to be carried out at appropriate intervals according to manufacturer specifications. Monitoring of electricity consumption to include a main as well as back-up metering system.
Enforcement mechanisms	Routine inspections to ensure performance tallies with design performance reported in building permit applications
Reference to relevant guidance documents	Provincial Building Code
The broader context/significance of the policy or action	Will reduce energy consumption and contribute to energy security
Outline of non-GHG effects or co-benefits of the policy or action	Improved air quality, reduced energy bills, occupant comfort, reduced burden on electrical infrastructure, reduced need for investment in expanding electricity generation, reduced land and water impacts of resource extraction and electricity generation.

5.3 Decide whether to assess an individual policy/action or a package of policies/actions

Chapter 5 also provides a description of the advantages and disadvantages of assessing an individual policy/action or a package of policy actions. Steps to guide the user in making this decision based on specific objectives and circumstances include identifying other related policies/actions that interact with the initial policy/action.

Taking the example of the building code policy, a policy mapping exercise is used to inform whether to assess an individual policy/action or a package of policies/actions for the hypothetical building code policy. To start with, the potentially interacting policies identified in table 5.2 would need to be preliminary analyzed to understand the nature of these interactions and determine whether to assess an individual policy/action or a package of policies/actions. This analysis can be brief and qualitative, since detailed analysis of interactions would be taken up in subsequent chapters. An illustrative example for the building code policy is provided below.

Table 5.5 Mapping policies/actions that target the same emission source(s)

Policy assessed	Targeted emission source(s)	Other policies/actions targeting the same source(s)	Type of interaction	Degree of interaction	Rationale
Building code	Fossil fuel combustion in grid connected or on-site heat / cooling generation systems	Renewable energy standards and incentives	Overlapping	Minor	Incentives for wool pellet heating and solar thermal already reduce primary energy demand.
		Water conservation	Overlapping	Minor	Reduces energy demand related to water use, but effect of information campaigns is very limited
		Energy taxes	Overlapping	Moderate	Increased prices encourage energy savings. Effects are moderate because of low price elasticity.
		Efforts to ensure compliance and enforcement of all other laws applicable to the sector	Overlapping and reinforcing	Moderate	Enhanced enforcement mechanisms applied to other policies can enhance the impact of other policies (thus reducing the incremental impact of the building code (overlapping)), but also enhance the impact of the building code (reinforcing).

Table 5.6 Criteria to consider for determining whether to assess an individual policy/action or a package of policies/actions

Criteria	Questions	Guidance	Evaluation
Use of results	Do the end-users of the assessment results want to know the impact of individual policies/actions, for example, to inform choices on which individual policies/actions to implement or continue supporting?	If "Yes" then undertake an individual assessment	Yes
Significant interactions	Are there significant (major or moderate) interactions between the identified policies/actions, either overlapping or reinforcing, which will be missed if policies/actions are assessed individually?	If "Yes" then consider assessing a package of policies/actions	Yes
Feasibility	Will the assessment be manageable if a package of policies/actions is assessed? Is data available for the package of policies/actions? Are policies implemented by a single entity?	If "No" then undertake an individual assessment	Yes
	For ex-post assessments, is it possible to disaggregate the observed impacts of interacting policies/actions?	If "No" then consider assessing a package of policies/actions	Yes

<u>Recommendation for the energy efficient building code:</u> Assessing energy taxes and the building code as a package would be an option. The other policies are expected to have minor to moderate overlapping effects. Whether to conduct a joint assessment will be strongly determined by the objective of the assessment and the intended use of results. The given example assumes that end users want to know the impact of the individual policy for decision-making purposes (see Table 5.6). In this case the policy would be evaluated individually.

Chapter 6: Identifying effects and mapping the causal chain

In this chapter, users are expected to identify all potential GHG effects of the policy or action and include them in a map of the causal chain.

6.1 Identify potential GHG effects of the policy or action

Using reliable literature resources (such as those mentioned in Box A below), combined with professional judgment or expert opinion and consultations etc. users can develop a list of all potential GHG effects of the policy or action and separately identify and categorize them in two categories: In-jurisdiction effects (and sources/sinks) and out-of-jurisdiction effects (and sources/sinks). In order to do this, users may find it useful to first understand how the policy or action is implemented by identifying the relevant inputs and activities associated with the policy or action.
For the building code policy example, an illustrative list of indicators and possible effects for the policy (by type) is provided below.

Table 6.1 Summary of inputs, activities, and effects for Building Code policy

Indicator types	Examples for building code policy
Inputs	Investment in enforcement activities
Activities	Number of inspections carried out Number of permits issued Number of permits refused
Intermediate effects	Number of residential and commercial buildings built according to the new building code Reduced energy use in buildings Increased demand for energy efficient building elements Rebound in energy use due to perceived savings/ costs Non-compliant building elements sold to other jurisdictions at lower prices Increased production of compliant building elements sold within the jurisdiction and to other jurisdictions Energy consumption increase for manufacture of compliant building elements Reduced energy consumption due to reduced manufacturing of non-compliant building elements Increased initial cost of construction of buildings
GHG effects	Reduced GHG emissions associated with reduced energy use due to some effects Increased GHG emissions associated with increased energy use due to some effects
Non-GHG effects	Enhancement of energy security Employment generation for local population Reduction in air pollution

Quantitative information may not be available for all elements identified in the table at the point of assessment and not all elements are relevant for the determination of the causal chain. However, creating a comprehensive list will not only provide support for the identification of effects, but also helps to design a robust performance monitoring (Chapter 10).
In a next step a comprehensive list of expected effects, based on the understanding of the design of the policy,

Table 6.2 Illustrative example of various effects for the building code policy

Type of effect	Effect
Intended effect	• Reduced GHG emissions due to reduced energy use by new buildings

Unintended effect	• Increased GHG emissions due to manufacturing of compliant building elements
In-jurisdiction effect	• Reduced GHG emissions due to reduced manufacturing of non-compliant building elements
Out-of-jurisdiction effect	• Reduced GHG emissions in other jurisdictions due to compliant building elements sold to other jurisdictions • Increased GHG emissions in other jurisdictions due to non-compliant building elements sold to other jurisdictions at lower prices
Short-term effect	-
Long-term effect	• Increased GHG emissions (rebound) due to energy savings

6.2 Identify source/sink categories and greenhouse gases associated with the GHG effects

Users are also expect to identify and report the list of source/sink categories and greenhouse gases affected by the policy or action.

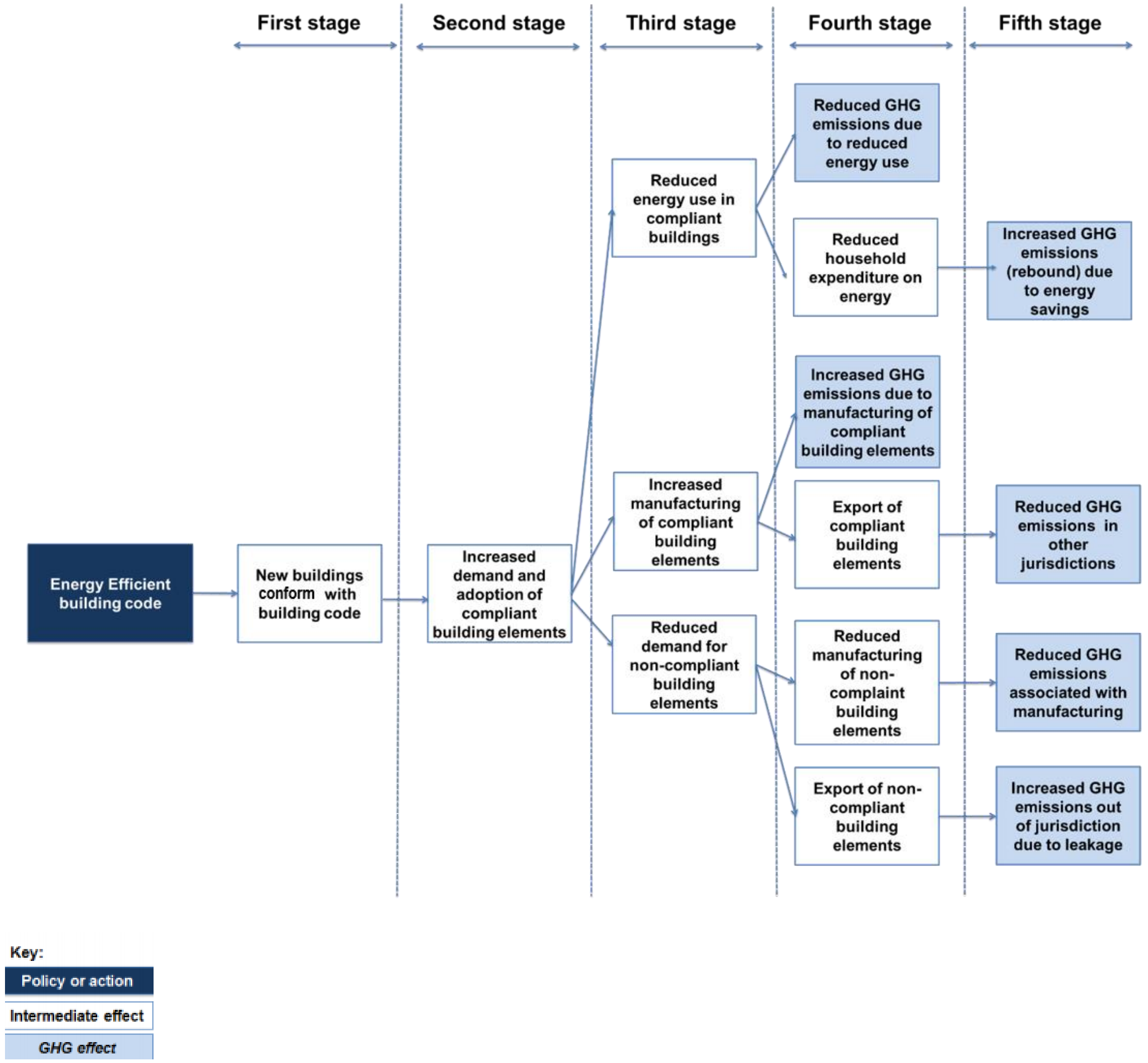
Table 6.3 Sources/sinks and greenhouse gases effected by a building code policy

Source category	Description	Examples of emitting equipment or entity	Relevant greenhouse gases
Buildings	Fuel combustion to meet energy requirement of building	Residential equipment that combusts fuels; electric grid that supplies electricity	CO_2, CH_4, N_2O
Manufacturing units	Industrial processes	Industrial facilities	CO_2, CH_4, N_2O, HFCs
Power generation units	Fuel combustion	Power plants	CO_2, CH_4, N_2O

6.3 Map the causal chain

Once effects have been identified, developing a map of the causal chain allows the user and relevant stakeholders to understand in visual terms how the policy or action leads to changes in emissions. Figure 6.3 presents a causal chain for the building code policy based on the effects identified above.

Figure 6.3 Mapping GHG effects by stage for a building code policy



There are a number of sector-specific resources such as guidance documents, tools, databases of projects etc. that can be referred to while brainstorming possible effects of policies in the sector. However, the extent of available literature and resources varies by policy type and geography. Some examples of these resources are provided in the in the methods and tools database on the GHG Protocol website, which can be filtered by sector. Most of these resources will not be applicable in their entirety, but select sections of these resources can provide a preliminary basis for further brainstorming and analysis.

Chapter 7: Defining the GHG assessment boundary

Following the standard, users are required to include all significant effects in the GHG assessment boundary. In this chapter, users determine which GHG effects are significant and therefore need to be included. The standard recommends that users estimate the likelihood and relative magnitude of effects to determine which are significant. Users may define significance based on the context and objectives of the assessment. The recommended way to define significance is "In general, users should consider all GHG effects to be significant (and therefore included in the GHG assessment boundary) unless they are estimated to be either minor in size or expected to be unlikely or very unlikely to occur".

7.1 Assess the significance of potential GHG effects

Effects that may be significant for policies in the sector include:

- Changes in number and size of buildings related to changes in population, building lifetime, population density, and consumer behavior and preferences
- Availability and cost of renewable energy systems
- Availability of efficient building technology and expertise
- Availability of renewable sources for electric or fuel cell related policies/actions
- Change in consumer behavior

For the building code example, an illustrative assessment boundary is described below. In general explanations for the exclusion of effects or gases should be provided unless effects are estimated to be minor and they are unlikely or highly unlikely to occur.

Table 7.3 Example of assessing each GHG effect separately by gas to determine which GHG effects and greenhouse gases to include in the GHG assessment boundary for the example policy

GHG	Likelihood	Relative magnitude	Included?
Reduced GHG emissions associated with energy use in new buildings			
CO_2	Very likely	Major	**Included**
CH_4	Very likely	Moderate	**Included**
N_2O	Very likely	Minor	Excluded
Increased GHG emissions (rebound) due to energy savings			
CO_2	Possible	Minor	Excluded
CH_4	Possible	Minor	Excluded
N_2O	Possible	Minor	Excluded
Increased GHG emissions associated with manufacturing of compliant elements			
CO_2	Very likely	Moderate	**Included**
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
HFCs	Very likely	Major	Included
Reduced GHG emissions associated with manufacturing of non-compliant elements			
CO_2	Very likely	Moderate	**Included**

GHG	Likelihood	Relative magnitude	Included?
CH_4	Very likely	Minor	Excluded
N_2O	Very likely	Minor	Excluded
Reduced GHG emissions in other jurisdictions due to compliant building elements exported			
CO_2	Very unlikely	Moderate	Excluded
CH_4	Very unlikely	Minor	Excluded
N_2O	Very unlikely	Minor	Excluded
Increased GHG emissions to other jurisdictions due to selling of non-compliant elements			
CO_2	Very unlikely	Moderate	Excluded
CH_4	Very unlikely	Minor	Excluded
N_2O	Very unlikely	Minor	Excluded

7.2 Determine which GHG effects, source/sink categories, and greenhouse gases are included in the GHG assessment boundary

Figure 7.3 Assessing each GHG effect to determine which GHG effects to include in the GHG assessment boundary for the example policy

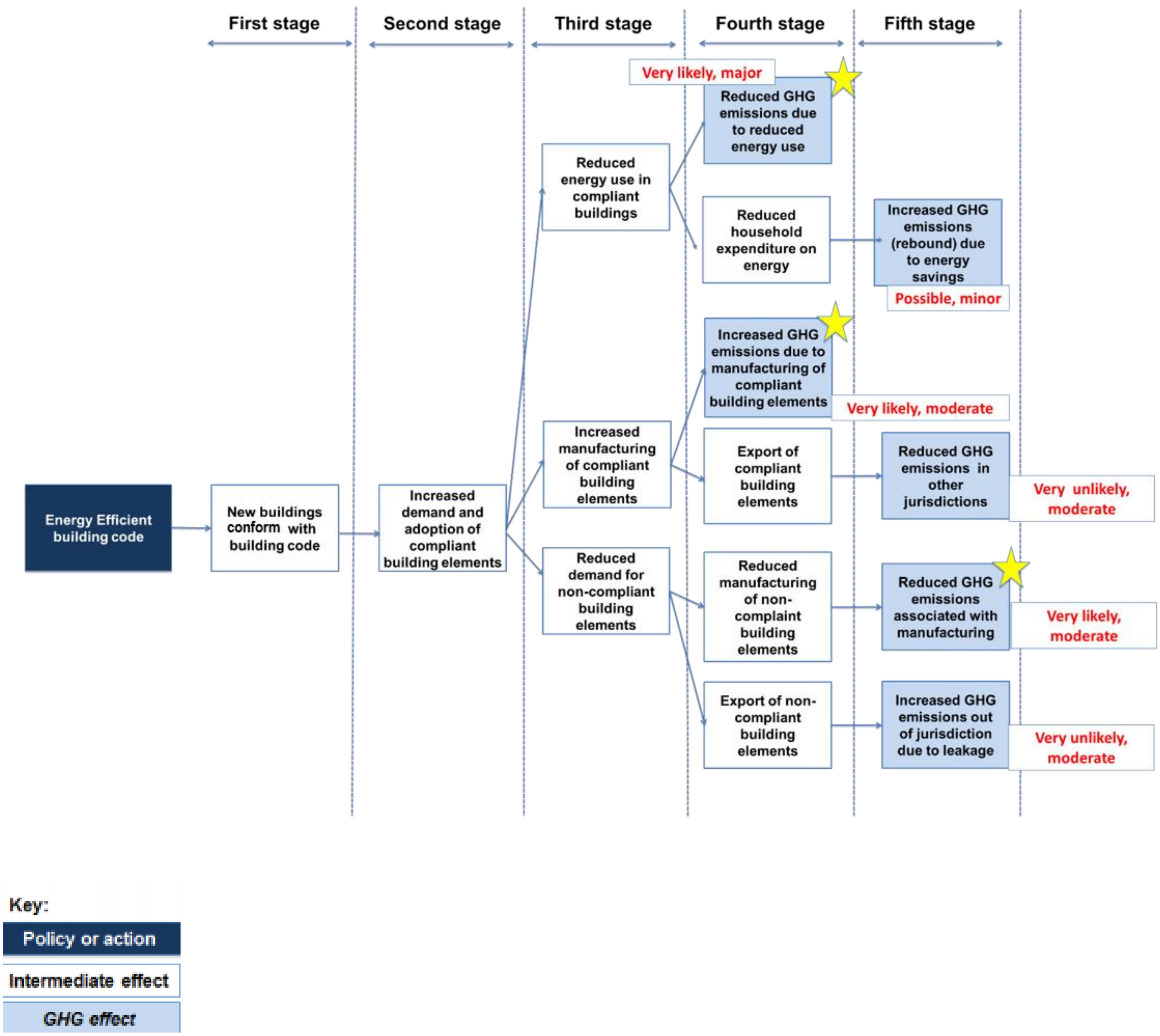


Table 7.4 List of GHG effects, GHG sources and sinks, and greenhouse gases included in the GHG assessment boundary for a building code policy

GHG effect		GHG sources	GHG sinks	Greenhouse gases
1	Reduced GHG emissions associated with energy use	Residential and commercial fuel combustion on-site or distributed (heating and cooling)	N/A	CO_2, CH_4
2	Increased GHG emissions associated with manufacturing of efficient elements	Fossil fuel combustion for supplying energy to manufacturing process, fugitive emissions from HFCs	N/A	CO_2, HFCs
3	Reduced GHG emissions associated with manufacturing of non-efficient elements	Fossil fuel combustion for supplying energy to manufacturing processes	N/A	CO_2

In addition to the resources mentioned in Chapter 6, there are other resources that can be used to determine the relative magnitude of effects for this chapter. For example, to estimate current energy use of buildings and construction trends, Government statistical offices, utility resources, surveys, market analysis, engineering analysis, equipment and material specifications are useful sources. Energy statistical offices, including the International Energy Agency, providing energy consumption by sector can also be helpful.

Chapter 8: Estimating baseline emissions

In this chapter, users are expected to estimate baseline emissions over the GHG assessment period from all sources and sinks included in the GHG assessment boundary. Users need to define emissions estimation method(s), parameter(s), driver(s), and assumption(s) needed to estimate baseline emissions for each set of sources and sinks.

8.4 Estimating baseline emissions using the scenario method

8.4.1 Define the most likely baseline scenario

Users should ensure that any energy savings that would have happened in the absence of the policy or action being assessed are not counted towards energy savings in the policy scenario. Users may use a baseline developed by an external party, use baseline values from published data sources, or develop new baseline values. In all cases, users should identify other policies and non-policy drivers that affect emissions in the absence of the policy or action. Examples of other policies and non-policy drivers relevant to the building sector are provided in Table 8.3 and Table 8.4. To determine savings that would have occurred anyway in the baseline because of baseline incentives, a survey may be carried out through interviews or other forms of communication with a statistically significant sample of building occupants.

Table 8.2 Examples of other policies or actions that may be included in the baseline scenario

Other policies	Sources of data for developing assumptions
Renewable energy incentives (non-building specific)	Government policies, regulations, or action plans; energy forecasting models
Voluntary sustainable building programs	Government policies or action plans, expert interviews
Building incentives/Home ownership incentives	Market assessment studies, expert interviews
Energy pricing instruments (taxes and subsidies)	Government policies, regulations, or action plans; energy forecasting models

Table 8.4 Examples of non-policy drivers that may be included in the baseline scenario

Non-policy drivers	Sources of data for developing assumptions
Consumer behavior, changes in preferences	Surveys, market analyses of past behavior
Economic activity, population and density	Market surveys, data, government statistical agencies
Energy prices	Market analyses, government statistical agencies

Data needs vary with the type of policy or action being implemented, however some of the common data needs for the sector are:

- **Baseline heating and cooling demand from buildings**: This may be available from government statistical offices (such as statistical units of energy or urban development ministries/ departments) or utility data (for example, national or regional grid electricity management bodies). Cooking and heating data may also be available in building permit applications that could be made available by the local development authority. Users should segment this information by fuel type to be able to calculate GHG emissions, since this would also allow fuel-switching to be accounted for, if appropriate.

- **Energy prices**: Changes in energy prices affect energy demand and may affect consumption in the baseline scenario. Energy price data may be available from government statistical offices, utilities, or international sources. However, projections in energy costs over the long term can be uncertain. Users should take into account uncertainty with a sensitivity analysis.
- **Construction trends and building data**: These may be available from government statistical offices' repository of publically available data and surveys. Projecting these trends may also be dependent on GDP and population projections. Construction size and count can also be a result of changing consumer behavior and preferences or incentives for home ownership or building in certain jurisdictions over others. Data may also be available from research surveys carried out by independent organizations and from building sector associations.
- **Electric grid emission factors**: Emission factors for the electricity provided to buildings can vary significantly from region to region. This may be available from government statistical offices or utilities, for example, emission factors may be available from the statistical unit of the ministry or department related to environment or energy or from state/national utilities.

8.4.2 Select a desired level of accuracy

Illustrative examples of estimating baseline emissions using low to high accuracy methods

- **Low accuracy**
  - Annual natural gas use per building in the baseline scenario based on national or international average values
  - Expected growth in new buildings based on national gross domestic product growth rate
- **Intermediate accuracy**
  - Annual natural gas use per building in the baseline based on subnational (state/province) or national average values
  - Expected growth in new buildings based on historical subnational (state/province) or national growth rate
- **High accuracy**
  - Annual natural gas use per building based on energy model using locally-specific building types, technology types, climates, etc.
  - Expected growth in new buildings based on modeled growth from economic forecasts, building permit data, and land use planning information for the jurisdiction

8.4.3 Define the emissions estimation method(s) and parameters needed to calculate baseline emissions

The following section illustrates the application of the standard to estimate baseline emissions for Effect 1, "Reduced GHG emissions associated with energy use," as identified in Table 7.4. Since each of the three effects that have been included in the assessment boundary target different emission sources, the emissions estimation method for each will be different. The first effect has been chosen to illustrate the methodology.

Equation 1a Estimating baseline emissions for reduced GHG emissions associated with energy use (Effect 1)

Baseline emissions in year$_{(a)}$ = ∑(Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$ affected by policy up to year$_{(a)}$ x Average annual fuel use by fuel type$_{(f)}$ per new building by type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ x Fuel type$_{(f)}$ emission factors)

Table A[3] Example of parameters and data sources to estimate baseline values for Effect 1

Parameter	Example sources of published data for baseline values
Number of new buildings per $type_{(b)}$ in climate $zone_{(z)}$	Building permits, historical development data, census demographic data, planning documents
Average annual fuel use by fuel $type_{(f)}$ per new building by $type_{(b)}$ in climate $zone_{(z)}$	Historical fuel use data Interviews with construction companies or experts
Fuel $type_{(f)}$ emissions factor for CO_2e	IPCC, emission factors used in national GHG inventories (from relevant government agency)
Fuel mix (share of each fuel type in total fuel use)	Fuel statistics from national Ministry of Energy or other relevant agency

Depending on the desired level of accuracy and availability of data, Equation 1a could also be expressed as follows:

Equation 1b Alternate equation for estimating baseline emissions for reduced GHG emissions associated with energy use (Effect 1)

Baseline emissions in $year_{(a)}$ = ∑(Number of buildings per $type_{(b)}$ in climate $zone_{(z)}$ affected by policy up to $year_{(a)}$ x Average annual fuel use per floor area by fuel $type_{(f)}$ per new building by $type_{(b)}$ in climate $zone_{(z)}$ up to $year_{(a)}$ x Average floor area per new building by $type_{(b)}$ up to $year_{(a)}$ x Fuel $type_{(f)}$ emission factors)

Box 8.2 Calculating the GHG effect directly

An alternate method is to calculate the GHG effect of the policy or action directly, without separately estimating baseline emissions and policy scenario emissions, which is called the "deemed savings" or "unit savings" approach. In this case the equation would be changed as follows:

Equation 2 Estimating 'deemed savings' for reduced GHG emissions from energy use for a building code

Emissions savings in $year_{(a)}$ = ∑(Average annual fuel savings by fuel $type_{(f)}$ per new building by $type_{(b)}$ in climate $zone_{(z)}$ x Number of buildings by $type_{(b)}$ in climate $zone_{(z)}$ affected by policy in $year_{(a)}$ x Fuel $type_{(f)}$ emission factors)

Examples of published data sources where the baseline values of these parameters can be sourced from are shown below:

Parameter	Sources of published data for baseline values
Number of buildings in climate $zone_{(z)}$ affected by policy in $year_{(a)}$	Building permits, historical development data, census demographic data, planning documents
Average annual fuel use by fuel $type_{(f)}$ per new building by $type_{(b)}$ in climate $zone_{(z)}$	Building modeling software, building engineering guidelines, developer surveys, literature, historical building survey or utility data
Fuel $type_{(f)}$ emissions factor for CO_2e (example: natural gas emission factor (CO_2e/TJ))	IPCC, national government assessments

[3] Table numbering differs, as there is no corresponding table included in the standard. The table is adapted from Table 8.7 in the standard.

8.4.4 *Estimate baseline values for each parameter*

Table 8.7 provides a hypothetical example for the parameter values used for the baseline calculation. For simplification, this example assumes that only one type of fuel (natural gas) is used), that there is only one type of building involved, and all buildings are in the same climate zone. For all other combinations of building types, fuels, and climate zones, the calculations would need to be repeated accordingly.

Table 8.7 Example of parameter values and assumptions used to estimate baseline emissions for the building code

Parameter	Baseline value(s) applied over the GHG assessment period	Methodology and assumptions to estimate value(s)	Data sources
Number of new buildings per type$_{(b)}$ in climate zone$_{(z)}$ (Example: number of new single family houses in hot climate zone)	50,000 per year (2012) Cumulative number of new buildings over assessment period: 1,071,800 by 2020	Constant annual new built rate of 10% based on historic trend (proportional to population growth)	National statistics bureau
Average annual fuel use by fuel type$_{(f)}$ per new building by type$_{(b)}$ in climate zone$_{(z)}$ (Example: average annual natural gas use per new single family house in hot climate zone)	10,000 kWh/building/year (2012) 9,000 kWh/building/year (2020)	Estimated decrease of 10% based on historic trend[4] and expert interviews	National energy statistics, expert interviews
Fuel type$_{(f)}$ emissions factor for CO_2e (Example: natural gas emission factor (CO_2e/TJ))	56.100 t CO_2e/TJ	Standard values	IPCC 2006
Fuel mix (share of each fuel type in total fuel use)	100% natural gas constant over assessment period	Extrapolating trends	National energy statistics on fuel use in residential buildings

8.4.5 *Estimate baseline emissions for each source/sink category*

The final step is to estimate baseline emissions by using the emissions estimation method identified in Section 8.4.3 and the baseline values for each parameter identified in Section 8.4.4.

[4] If assumptions are based on historic trends, the underlying data that were used to determine the trend should be provided in additional material such as an annex.

Baseline emissions$_{2020}$ = 1,071,800 buildings x 9,000 kWh/building x 0.0000036 TJ/kWh[5] x 56.1 t CO_2e = 1,984,147 t CO_2e = 1.98 Mt CO_2e

In a full assessment this calculation would need to be repeated for each year within the assessment period as far as data is available.

8.6 Aggregate baseline emissions across all source/sink categories

Table 8.9 provides an illustrative example of the results of the assessment for all effects included in the assessment boundary, assuming similar calculation steps as those used for Effect 1 in Section 8.4 were carried out for each of the three effects.

Table 8.9 Example of aggregating baseline emissions for the building code policy in 2020[6]

GHG effect included in the GHG assessment boundary	Affected sources	Baseline emissions in 2020
1. Reduced GHG emissions associated with energy use	Residential and commercial fuel combustion on-site or distributed (heating and cooling)	1.98 Mt CO_2e
2. Increased GHG emissions associated with manufacturing of efficient elements	Fossil fuel combustion for supplying energy to manufacturing process, fugitive emissions from HFCs	0.11 Mt CO_2e
3. Reduced GHG emissions associated with manufacturing of non-efficient elements	Fossil fuel combustion for supplying energy to manufacturing processes	0.27 Mt CO_2e
Total baseline emissions		**2.36 Mt CO_2e**

[5] Conversion factor. 1 kilowatt hour = 0.0000036 terajoules.
[6] Numbers for effects 2 and 3 are illustrative.

Chapter 9: Estimating GHG effects ex-ante

In this chapter, users are expected to estimate policy scenario emissions for the set of GHG sources and sinks included in the GHG assessment boundary based on the set of GHG effects included in the GHG assessment boundary. Policy scenario emissions are to be estimated for all sources and sinks using the same emissions estimation method(s), parameters, parameter values, GWP values, drivers, and assumptions used to estimate baseline emissions, except where conditions differ between the baseline scenario and the policy scenario, for example, changes in activity data and emission factors.

9.2 Identify parameters to be estimated

Table A in Chapter 8 forms the basis for determining which parameters are affected by the policy. To do this, the methodology to determine significance outlined in Chapter 7 can be used. Each parameter identified in the baseline scenario is evaluated based on the likelihood of being affected and relative magnitude of the expected effect. Table 9.1 illustrates this method for the example of the building code. The policy will affect the fuel use of buildings, as this is its main objective. Depending on the level of ambition of the building code and the involved additional cost for buildings, the policy could also affect the number of new buildings built. However, there are many other factors determining demand for new buildings, so in the specific example the effect is expected to be unlikely and estimated to be minor.

Table 9.1 Example of identifying affected parameters to estimate policy scenario values for effect 1 and source category 'buildings' of the building code

Parameter	Likelihood	Relative magnitude
Number of new buildings per type$_{(b)}$ in climate zone$_{(z)}$	Unlikely	Minor
Average annual fuel use by fuel type$_{(f)}$ per new building by type$_{(b)}$ in climate zone$_{(z)}$	Very likely	Major
Fuel type$_{(f)}$ emissions factors	-	-
Fuel mix	Unlikely	Minor

To determine the expected effect on a parameter or define parameter values, the user can use the specifications made in the building code as a basis. Directly using the energy use restrictions implied in the standard would deliver the maximum effect. However, assumptions related to non-compliance rates may be realistic, which would reduce effectiveness. These could be implemented by increasing the assumed average fuel use of new buildings according to transparent calculations. Additional to the overall fuel use assumptions on the fuel mix are implicitly required. As the policy targets overall energy use, not emissions, no significant effect on the fuel mix can be expected. Baseline values should be applied.

9.4 Estimate policy scenario values for parameters

Once the affected parameters are determined the parameter values for the policy scenario can be determined. All other parameters remain as in the baseline scenario. Table 9.2 provides an example.

Table 9.2 Example of reporting parameter values and assumptions used to estimate ex-ante policy scenario emissions for the building code

Parameter	Baseline value(s) applied over the GHG assessment period	Policy scenario value(s) applied over the GHG assessment period	Methodology and assumptions to estimate value(s)	Data source(s)
Average annual fuel use by fuel type$_{(f)}$ per new building by type$_{(b)}$ in climate zone$_{(z)}$	10,000 kWh/building/year (2012) 9,000 kWh/building/year (2020)	10,000 kWh/building/a (2012) 8,000 kWh/building/a (2020)	Policy scenario value according to building code regulation and average building size of 100 m^2	National statistics bureau, building code

9.5 Estimate policy scenario emissions

Once parameter values have been determined, the same equations as used for the calculation of baseline values can be used to derive the policy scenario values:

Policy scenario emissions$_{2020}$ = 1,071,800 buildings x 8,000 kWh/building x 0.0000036 TJ/kWh x 56.1 t CO_2e = 1,731,686 t CO_2e = 1.73 Mt CO_2e

9.6 Estimate the GHG effect of the policy or action (ex-ante)

After determining the GHG emissions for the policy scenario for each source category, the change resulting from the policy can be determined. Table 9.3 provides an overview of the results.

Table 9.3 Example of estimating the GHG effect of the building code[7]

GHG effect included	Affected sources	Policy scenario emissions	Baseline emissions	Change
1. Reduced GHG emissions associated with energy use	Residential and commercial fuel combustion on-site or distributed (heating and cooling)	1.73 Mt CO_2e	1.98 Mt CO_2e	**-0.25 Mt CO_2e**
2. Increased GHG emissions associated with manufacturing of efficient elements	Fossil fuel combustion for supplying energy to manufacturing process, fugitive emissions from HFCs	0.30 Mt CO_2e	0.11 Mt CO_2e	**0.19 Mt CO_2e**
3. Reduced GHG emissions	Fossil fuel combustion for	0.16 Mt CO_2e	0.27 Mt CO_2e	**-0.11 Mt CO_2e**

[7] Numbers for effects 2 and 3 are illustrative.

associated with manufacturing of non-efficient elements	supplying energy to manufacturing processes			
Total emissions / Total change in emissions		**2.19 Mt CO_2e**	**2.36 Mt CO_2e**	**-0.17 Mt CO_2e**

Note: The table provides data for the end year in the GHG assessment period (2020).

Box B.1 Addressing policy interactions

For an ex-ante assessment, energy and GHG calculations should incorporate policies that substantially affect the expected results of the policy, per Appendix B of the standard. It can be difficult to identify if two policies have a reinforcing or overlapping impact without detailed computations. If policies are a package and the individual contribution of each policy is not determined, the analyst could consider the combined impact on the parameters. For example, a green electricity portfolio standard would change the emissions per kWh used by an analysis of electricity savings from a building lighting efficiency regulation over time. To address this combination, the electricity emissions factor should be adjusted in a scenario with both policies. The rest of the policies not part of a combined package should be considered in the baseline scenario of the analysis.

An example policy interaction matrix for the parameter Natural gas use is provided in Figure B.1.

Figure B.1 Example policy interaction matrix

	Parameter: Natural gas use				
	Energy Efficiency building code	Appliance standards	Green building standards	Behavior change incentives	Energy taxes
Energy efficiency building code	N/A				
Appliance standards	-	N/A			
Green building standards	- - -	+	N/A		
Behavior change incentives	U	++	++	N/A	
Energy taxes	--	+	+++	++	N/A

Key:

- Independent: 0
- Overlapping: - - - major/- - moderate/ - minor interaction

- Reinforcing: +++ major/++ moderate/+ minor interaction
- Uncertain: U

Prior to detailed computations, this matrix only provides an indication of the type and level of interaction between policies which effects the value of any given parameter in the emissions estimation equation. However, there may be several situations in which the type or level interaction may not be clear at this stage, and can be mentioned as uncertain in the matrix. In this particular example, given that there may be large overlapping effects between the policy being assessed and the baseline policies (for example, building code and Green building standards), it is necessary to look closely at how the policies effect the parameter value, and how it varies over time due to the contribution of each policy. Similarly, large reinforcing effects are predicted between baseline policies, and these need to be studied closely to determine baseline values of the parameter.

Chapter 10: Monitoring performance over time

In this chapter, users are required to define the key performance indicators that will be used to track performance of the policy or action over time. Where relevant, users need to define indicators in terms of the relevant inputs, activities, intermediate effects and GHG effects associated with the policy or action.

10.1 Define key performance indicators

Some typical indicators for common policies in the sector are shown in the table below.

Table 10.1 Examples of indicators

	Building energy code	Renewable energy tax incentive	Appliance standards and labeling program	Research and development for new low-GHG refrigerant
Input indicators	• Money spent to implement the program	• Money spent to implement the program	• Money spent to implement the program	• Money spent to implement the program
Activity indicators	• Number of inspections carried out • Number of permits issued • Number of permits refused • Number of provinces/ municipalities/ urban jurisdictions adopting the code	• Financial resources paid out as incentive • Number of successful applications for the incentive	• Energy efficient equipment sold	• Number of research projects funded • Number of public institutions funded • Number of private institutions/ companies funded
Intermediate effect indicators	• Average energy use per floor area for new buildings • Reduction in building energy use for new buildings compared to reference year	• Change in fossil fuel usage (kWh) • Share of alternative energy sources (%)	• Average energy use by new equipment • Reduction in energy use compared to reference year	• Amount of new refrigerant deployed • Amount of old refrigerant avoided
GHG effects	• Reduction in GHGs per new building • Reduction in GHGs	• Reduction in GHGs per kWh • Reduction in GHGs	• Reduction in GHGs per piece of equipment • Reduction in GHGs	• Reduction in GHGs per kg of new refrigerant • Reduction in GHGs
Non-GHG effects	• Improvement in air quality	• Increase in local employment	• Household disposable income from	• Enhancement of indigenous manufacturing

			energy savings	capacity (number of new manufacturing units)

10.4 Create a monitoring plan

A monitoring plan is important to ensure that the necessary data is collected and analyzed. Table 10.5 provides an example for a monitoring plan for the building code policy.

Table 10.5. Examples of information contained in the monitoring plan of the building code policy

Indicator or parameter (and unit)	Source of data	Monitoring frequency	Measured/modeled/ calculated/estimated (and uncertainty)	Examples of responsible entity
Number of buildings following the code in climate zone$_{(z)}$ by type and m^2 in year$_{(a)}$	Government information system	Annual	Measured (Low uncertainty)	Ministry of Urban Development statistical office
Annual fuel use per fuel type, building type and climate zone$_{(z)}$	Sampled metering and survey	Annual	Measured for select buildings and estimated for the rest (Medium uncertainty)	Ministry of Energy, statistics division
Fuel emission factors	IPCC, National Government Assessments	Annual[8]	Estimated	Ministry of Energy, statistics division
Energy cost savings	Official sources on energy pricing and subsidies	Annual	Measured and calculated (Low uncertainty)	Ministry of Energy, statistics division

[8] Emission factors do not typically change often. However, analysts monitoring a policy or action should regularly check if there are new scientific findings at international or national level that would require changes in emission factors.

Chapter 11: Estimating GHG effects ex-post

A number of ex-post assessment methods have been described in this chapter, which can be classified into two broad categories: bottom-up and top-down methods. For the buildings sector, the applicability of top-down or bottom-up methods is significantly influenced by the type of policy and objectives of the assessment.

11.2 Select an ex-post assessment method

The applicability of individual ex-post quantification methods for the sector and illustrative sources of data are discussed in Table 11.1.

Table 11.1 Applicability of ex-post assessment methods to the building sector

Bottom-up methods	Applicability and potential data sources
Collection of data from affected participants/sources/other affected actors	• Applicable. Fuel use can be measured through meters (e.g., electricity, natural gas, or oil delivered). However, data collection can be challenging if there are a large number of individual buildings to collect data from. In such cases, sampling can be used to collect data from representative samples of buildings, by building type. • Electricity use can also be measured through metered demand from consumers at the utility level. Access to data disaggregated by building type and age of building depends on specific national circumstances.
Engineering estimates	• Applicable. Parameter values can be derived from specifications in the building code and data/assumptions on the number of new, compliant buildings by building type.
Deemed estimate	• Applicable. It can be used to estimate energy savings per building, which can then be aggregated across buildings.
Methods that can be bottom-up or top-down depending on the context	**Applicability and potential data sources**
Stock modeling	• Applicable. It can be used to estimate the use of new building designs, products, and technologies as well as changes in consumer purchases and renewable energy systems.[9]
Top down methods	**Applicability and potential data sources**
Monitoring of indicators	• Applicable.
Economic modeling	• Applicable. It can be used when data are available on construction and construction trends and assumptions can be made about the effect of the policy on overall use of energy in the building sector relative to the baseline scenario.

With reference to the building code policy, both bottom-up and top-down methods are applicable. Top-down methods may include jurisdiction-wide assessments of new buildings using tax, permit, or census data and combining it with models of building energy use, technology sales data, or statewide energy use data. Bottom-up methods may include building-level performance reports, such as data monitored by building facility owners or utility providers.

[9] Stock modeling is applicable for the sector, but requires detailed data on the building stock or specific equipment deployment, which may not be available in many countries, particularly in developing countries.

11.3 Select a desired level of accuracy

Examples of how to implement ex-post quantification methods using approaches ranging from low to high accuracy for the policy example are described below:

- **Example of a low accuracy method:** Using deemed estimates and engineering estimates to determine estimated savings based on the number of new and substantially altered buildings covered under the policy and the estimated savings for each building.
- **Example of an intermediate accuracy method:** Combining the approach of a low accuracy method with utility data and surveys to supplement engineering data with real-world performance data.
- **Example of a high accuracy method:** Conducting an ex-post assessment including carrying out energy audits and utility bill analysis in a statistically significant sample of buildings.