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Buildings Efficiency Guidance

Guidance for assessing the greenhouse gas impacts of buildings policies

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How to quantify the GHG impacts

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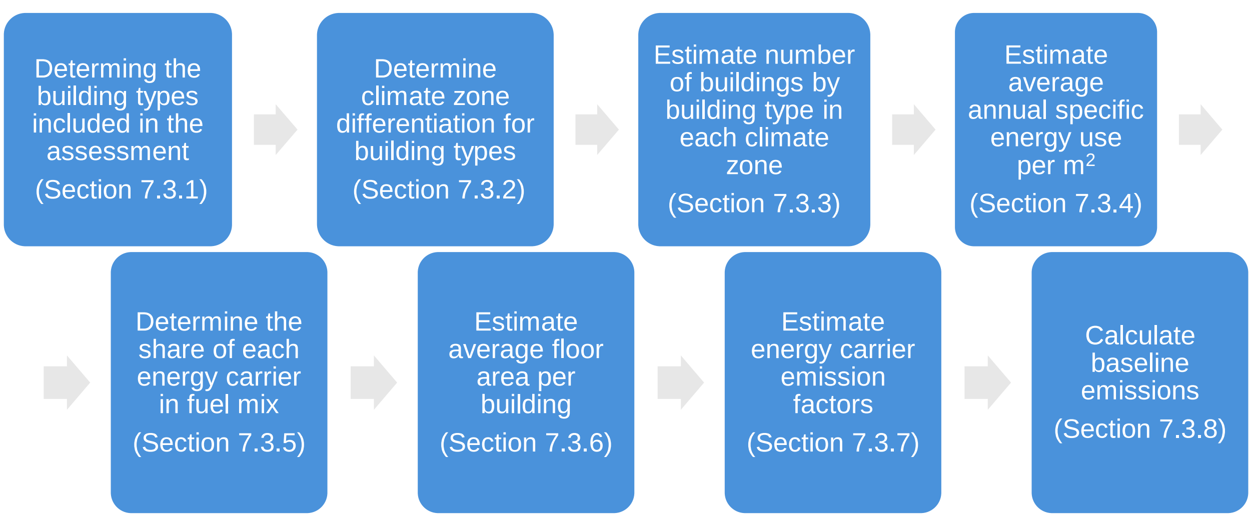
7. ESTIMATING THE BASELINE SCENARIO AND EMISSIONS

Where the user's objective is to estimate the GHG emission reductions achieved by a policy, the determination of a baseline scenario is necessary. The baseline scenario represents what would have happened in the absence of the policy intervention. Baseline emissions are estimated according to the most likely baseline scenario. Estimating the GHG impacts of a policy involves comparing the baseline emissions to the policy emissions.

Sections 7.1 and 7.2 of this chapter provide introductory guidance, with the main guidance steps being in Section 0. Where users do not need to estimate baseline emissions (i.e., where they choose only to estimate the sectoral emission level to compare to a target), they can use Chapter 7 to familiarise themselves with the estimation approach in Section 0. This approach is also used for the ex-ante and ex-post assessments (Chapter 8 and Chapter 9).

Figure 7.1: Overview of steps in the chapter (set out in Section 0)



Checklist of key recommendations:

- Identify key drivers that affect the baseline scenario and to determine the baseline scenario that represents the conditions most likely to occur in the absence of the policy
- Determine which building use(s) and building stock type(s) to include in the baseline emissions estimation
- Calculate baseline emissions for each year of the assessment period based on the estimated parameter values (using Equation 7.1)

7.1 Considerations for determining the baseline scenario

Estimating baseline emissions requires the determination of a baseline scenario. For each GHG source category included in the GHG assessment boundary, users determine a baseline scenario that represents the conditions most likely to occur in the absence of the policy being assessed.

It is a *key recommendation* to identify key drivers that affect the baseline scenario and determine the baseline scenario that represents the conditions most likely to occur in the absence of the policy. The most likely baseline scenario depends on drivers that affect emissions in the absence of the policy being assessed. These drivers can be divided into two types: other policies or actions and non-policy drivers.

Users can either use existing baseline scenarios from published data sources or develop their own baseline scenario. For existing baseline scenarios, it is important to ensure that the underlying drivers and assumptions are available, otherwise it may be difficult to establish whether this baseline scenario is distinct (i.e., does not overlap) with the policy scenario. This should be carefully considered before choosing an existing baseline scenario.

Whether using an existing baseline scenario or determining a new one, users should consider the following questions:

- Which other policies and actions should be included, what timeframes do they have and how do they interact with policies analysed under the policy scenario (see Table 7.1)?
- Which non-policy drivers should be included (see Table 7.2)?
- How would the sector have developed without the policies (e.g., rate of construction of new buildings, rate of demolition and rate of renovation of existing buildings)?

Including other policies and actions

Table 7.1 provides examples of policies and actions that may be relevant for inclusion in the baseline scenario. Users should ensure that energy savings that would have happened in the absence of the policy being assessed are not counted toward energy savings in the policy scenario. Where subnational policies exist that are not included in the policy assessment (e.g., policies on the city level introduced by some municipalities), these can also be included in the baseline scenario.

Table 7.1: Examples of other policies or actions that may be relevant for inclusion in the baseline scenario

Policies	Examples	Sources of data for developing assumptions
Renewable energy incentives (non-building specific)	Incentives for renewable electricity generation (e.g., a feed-in tariff for rooftop PV) might exist	Government policies, regulations, or action plans; energy forecasting models
Building incentives and home ownership incentives	Policies exist that provide an incentive for home ownership, increasing ownership levels	Market assessment studies, expert interviews
Energy pricing instruments (taxes and subsidies)	Subsidies for fuel for low-income households which may incentivise households to use fossil fuels for heating and cooling	Government policies, regulations, or action plans; energy forecasting models

Including non-policy drivers

Users should also develop assumptions on non-policy drivers that are relevant to the baseline scenario. Table 7.2 provides examples of non-policy drivers.

Table 7.2: Examples of non-policy drivers that may be relevant for inclusion in the baseline scenario

Non-policy drivers	Examples	Sources of data for developing assumptions
Consumer behaviour, changes in preferences	Higher ecological awareness in society affects consumer preferences on energy-efficient housing	Surveys or market analyses of past behaviour
Economic activity	Higher economic growth and economic prosperity might lead to increased activity in the buildings sector Interest rate without policy intervention might critically determine activity in the buildings sector	Market surveys, government statistical agencies
Energy prices	Increasing fossil fuel prices in international markets might spur domestic investments in energy efficiency in the buildings sector due to increased saving potential	Market analyses, government statistical agencies
Demographic shifts (population and density)	Increasing the size of a country's population leads to increased demand for housing, thus might lead to increased activity in the buildings sector	Market analyses, government statistical agencies

Further data considerations for baseline scenarios

The sources of data for developing assumptions on drivers and trends can include:

- Direct information on policies, such as the descriptions of government policies or regulations themselves, or action plans
- Secondary literature analysing national trends in the sector, including studies by national research institutes such as government-funded studies or independent assessments with projections on buildings sector development
- National modelling exercises (e.g., country-specific modelling exercises)
- Expert interviews

Data needs vary with the type of policy being implemented. Table 7.3 describes sources for some common data needs.

Table 7.3: Data sources for common data needs

Data need	Description
Construction and building stock trends and building data	Construction trends and building data may be available from government statistical offices' repository of publicly available data and surveys, including the rate of construction of new buildings, the demolition rate of existing buildings, and the rate of renovation of existing buildings. Projections of these trends may be dependent on GDP and population projections. Construction size and count can also be a result of changing consumer behaviour and preferences or incentives for home ownership. Data may also be available from research surveys carried out by independent organisations and from buildings sector associations.
Baseline heating and cooling demand from buildings	This may be available from government statistical offices (e.g., statistical bureaus in energy or urban development ministries or departments) or other statistical agencies. Heating data may also be available in building permit applications that are often available from the local development authority. In some instances, regulatory policies such as building codes might already make assumptions on baseline developments in the sector when the policy's specifications are defined relative to a baseline value. Users should segment this information by fuel type in order to calculate GHG emissions, since this allows 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 highly uncertain. Users should consider uncertainty with a sensitivity analysis.
Electricity grid emission factors	Emission factors for the electricity provided to buildings can vary significantly from region to region. These factors 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 or national utilities.

It is important that users explain their underlying assumptions transparently. Users should consider determining multiple baselines, given the large degree of uncertainty about future developments. This approach produces a range of possible emission reductions scenarios. At a minimum, the user should perform uncertainty analyses to understand how the results would change depending on the underlying drivers.

Users that are assessing the sustainable development, transformational or other GHG impacts of the policy should use the same underlying assumptions about macroeconomic conditions, demographics and other non-policy drivers. For example, if GDP is a macro-economic condition needed for assessing both the job impacts and economic developments impacts of a buildings policy, users should use the same assumed value for GDP over time for both assessments.

Box 7.1 describes some further considerations for the determination of baseline scenarios.

Box 7.1: Considerations for the determination of baseline scenarios

Users should exercise caution when determining baseline scenarios. The determination of baseline scenarios requires assumptions about future sectoral, economic, social and political developments, as well as assumptions about national policies. These can be difficult to predict.

It is important to note that there is an additional element of uncertainty in the determination of a baseline scenario compared to the policy scenario. Historically, there has been some controversy surrounding the determination of baseline scenarios and the existence of incentives to overstate baseline emissions.

Conservativeness is important for baseline scenarios, since a range of possible values and probabilities exist in the determination of baseline scenarios. Users may want to determine a range of possible baseline scenarios and, where necessary, using the lower end of this range.

7.2 Introduction to equation for calculating baseline emissions

This section provides an overview of the key equation used for calculating baseline emissions. The parameters for this equation are estimated in Section 0 and then applied to the equation to yield the baseline emissions for a given year of the assessment period.

It is *a key recommendation* to determine which building use(s) and building stock type(s) to include in the baseline emissions estimation. Users can opt to estimate baseline emissions for all building uses (residential, commercial, public), all building stock types (new buildings, existing buildings with retrofit, existing buildings without retrofit), only the building use and building stock types addressed by the policy being assessed, or any subset or combination thereof. For example, if a building code for new buildings is being assessed (and that is the only policy being assessed), it may be sufficient to estimate baseline emissions only for the new building stock. Alternatively, the user could choose to estimate baseline emissions from both new and existing buildings.

Equation 7.1 provides the equation for calculating baseline emissions. This equation is applied separately to each building stock types included in the assessment. The estimation should be done individually for each year of the assessment period.

Equation 7.1: Equation for calculating baseline emissions

$$
\begin{aligned}
&\text{Baseline emissions in year}_{(a)} \\
&= \sum(\text{Number of buildings per building type}_{(b)}\text{in climate zone}_{(z)}\text{ up to year}_{(a)} \\
&\times \text{ Average annual specific energy use per m}^2\text{ per building type}_{(b)}\text{ in climate zone}_{(z)}\text{ up to year}_{(a)} \\
&\times \text{ Share of energy carrier}_{(f)}\text{in fuel mix per building type}_{(b)}\text{ in climate zone}_{(z)}\text{ up to year}_{(a)} \\
&\times \text{ Average floor area per building per building type}_{(b)}\text{ in climate zone}_{(z)}\text{ up to year}_{(a)} \\
&\times \text{ Energy carrier}_{(f)}\text{ emission factors})
\end{aligned}
$$

Where the unit types for each parameter are as follows:

Number of buildings per building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ (integer)

Average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ (kWh per m^2)

Share of energy carrier$_{(f)}$ in fuel mix (% of total fuel mix)

Average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ (m^2 per building)

Energy carrier$_{(f)}$ emission factors (g CO_2 per kWh)

The types of buildings covered by the *number of buildings* parameter will vary depending on the building stock type being assessed, as described in Table 7.4.

Table 7.4: Parameters for building stock types

Building stock type	Parameter
Existing building stock without retrofit	Σ number of existing buildings by building type(b) in climate zone(z) not affected by any retrofit up to year(a)
Retrofitted building stock	Σ number of retrofitted buildings per building type(b) in climate zone(z) up to year(a)
New building stock	Σ number of new buildings by building type(b) in climate zone(z) up to year(a)

Instead of multiplying the *average annual specific energy use per m^2 per building type$_{(b)}$ in climate zone$_{(z)}$* with *average floor area per building type$_{(b)}$ in climate zone$_{(z)}$*, users can opt to use the *average annual energy use per building by building type$_{(b)}$ in climate zone$_{(z)}$*. This decision can be based on the country-specific policy set up (e.g., if building efficiency regulations directly specify the total average annual energy use per building) or household density considerations.

In many cases, detailed buildings stock data required for Equation 7.1 are not readily available in national statistics, databases or yearbooks. In such cases, users might need to make assumptions for the required data (e.g., based on data from a neighbour country) or identify available data (e.g., GDP estimates) and make assumptions to link such data to data required for the intended calculation (e.g. residential floor space). Box 7.2 provides a possible aggregated approach to obtain data for calculations.

Box 7.2: Aggregated approach to obtain data required for calculations

The following data collection approach is a simplified, illustrative concept for conducting remote data collection if limited building sector data are available. Users should acknowledge the limitations that this approach has on quality, preciseness and validity of data used for calculations.

Step 1: Collect available data on energy use in the buildings sector, and other available data

Identify easily accessible data sources for the following:

- ***Energy data by energy carrier in the residential, commercial and public buildings sector (historical and projections)***:
  - Accessible historical data might be available for many countries in national energy statistics or balances, and is available for all countries in the International Energy Agency (IEA) Energy Balance[1]
  - For some countries, UNFCCC submissions (e.g., Biennial Reports, Biennial Update Reports, National Communications) provide projections on energy demand
  - Users can also look for other national and international level scenario analysis on energy demand in the buildings sector
- ***GDP (historical and projections)***:
  - Accessible historical data and future projections might be available in national statistics or provided in the Global Economics Prospects outlook by the World Bank[2]
  - For some countries the submissions to the UNFCCC (e.g. Biennial Reports, Biennial Update Reports, National Communications) provide projections for GDP
- ***Population (historical and projections)***:
  - Accessible historical data and future projections might be available in national statistics or provided in the World Population Prospects by the United Nations Population Division[3]
  - For some countries the submissions to the UNFCCC (e.g. Biennial Reports, Biennial Update Reports, National Communications) provide projections on GDP

Step 2: Generate energy use data at the level required for calculations (if applicable)

Where energy data for the buildings sector are not available, users need to make informed assumptions to generate the required data for baseline projections of *average annual specific energy use per m^2* and *share of energy carrier in fuel mix*.

Historical energy data by energy carrier in buildings sector (residential and commercial/public) are generally available for all countries either through national statistics or the IEA Energy Balances. However, users might face missing data on baseline projections for energy data by energy carrier, energy data by end-use (historical and projections), and end-use specific energy use data per carrier (historical and projections). Depending on the available data in the specific country context, users should make the following informed assumptions on:

- Baseline projections for energy data by energy carrier
  - Possible options: continuation of historical trend, or growth rates of external scenario

[1] Available at: https://www.iea.org/statistics/relateddatabases/worldenergystatisticsandbalances/

[2] Available at: https://data.worldbank.org/data-catalog/global-economic-prospects

[3] Available at: https://esa.un.org/unpd/wpp/

applied to historical data

- End-use specific energy use data per carrier (both for historical and future years)
    - Possible options: household survey in buildings sector (if available), using data from a neighbouring country (if available), or informed expert judgement

The following simplified example explains how users can conduct such calculations.

Simplified example for Country A for baseline projections for residential sector to 2030

- Only historical energy data by energy carrier to 2015 available via IEA Energy Balances
- Conversion from MJ to kWh with factors as provided by the IEA[4]
- Assumption 1: Baseline projection for energy data by energy carrier to 2030 based on national energy use scenario with growth rates applied to last historical data point
- Assumption 2: Split of end-use specific energy use data by carrier for last historical year (2015) assumed to continue in future
    - Historical split for 2015 based on informed assumption from national survey
    - Alternatives: IEA Energy Technology Perspectives (ETP) report series for a limited number of countries, expert judgement, or benchmarking country
- Calculation of baseline values of *average annual specific energy use per m²* to 2030 including energy use for space heating and cooling, appliances related to heating, cooling and hot water, as well as lighting (while excluding cooking and other appliances not related to heating, cooling and hot water)
- Calculation of baseline values of *share of energy carrier in fuel mix* to 2030

Step 3 – Generate other data required for calculations (if applicable)

Besides missing energy data by end-use, users might face limited availability for other data in the buildings sector, such as for residential floor space. Users should make informed assumptions based on expert judgement or external scenarios applicable to obtain such data. Such assumptions should always link the required data for calculations to existing data available. Users should always carefully examine the obtain data results for validity and compare with other available data or benchmark with similar countries if possible.

For the example of residential floor space, users might use a generalised relationship between GDP, population and residential floor space as specified by Isaac and Van Vuuren (2009).[5] The formula to estimate residential floor space per capita based on available GDP data is as follows:

$$y = 6.33\ Ln(x) - 28.95$$

where $y = \frac{m^2}{capita}$ and $x = \frac{GDP}{capita}$ *(in thousand USD)*

Users should examine the obtained estimates for historical and projected floor space for general plausibility. If possible, the results should be compared other available data points. Users should be aware that results of quantification might significantly be impacted by data resulting from such simplified approaches.

[4] Available at: https://www.iea.org/statistics/resources/unitconverter/

[5] Available at: https://ideas.repec.org/a/eee/enepol/v37y2009i2p507-521.html

7.3 Estimate baseline emissions

It is a *key recommendation* to calculate baseline emissions for each year of the assessment period based on the estimated parameter values (using Equation 7.1). The sections below provide a series of steps for estimating the parameter values in the equation. Each step should the followed, though different approaches can be used, as needed for the specifics of the policy being assessed. The steps are illustrated with an example policy described in Box 7.3.

Box 7.3: Example policy used to illustrate the steps for calculating baseline emissions

The policy being assessed exclusively addresses new buildings in the residential sector. The Ministry of Building and Housing opts to conduct baseline estimation for:

- **Building use: residential buildings only**. No baseline estimation is conducted for commercial or public buildings.
- **Building stock type: new buildings only**. No baseline estimation is conducted for existing building stock without retrofit or retrofitted building stock.

7.3.1 Step 1: Determine the building types included in the assessment

Determine the building type categories included in the assessment (building type$_{(b)}$). The categorisation of building types varies country by country and can be influenced by the following considerations:

- **Policy relevance**: Users can base their decision on policies selected in Chapter 5. When policies differentiate between different building types (e.g., efficiency specifications for different building types in a building code), this typology can be used.
- **Existing national classifications**: Users can use existing classifications of building types for the country. For example, many European countries have already established country-specific categorisations of building types.[6] This approach might increase coherence with existing regulations in the sector.
- **Data availability**: Users can determine building types based on available data. When data on the national building stock and building types is limited, it might be preferable to use less granular building type categorisation.

Consideration of the above should take into account the desired level of accuracy and the resources available to undertake the assessment. Users should carefully determine which building categorisation linked to the different considerations above and transparently document their decisions. Where users estimate baseline emissions in the commercial buildings sector, they should be aware of the diversity of different commercial building types. The US Energy Information Administration (EIA), for example, provides a comprehensive classification of commercial building types and subcategories.[7] It is important to ensure that the typology of buildings is consistent between the estimation of baseline emissions and the ex-ante and/or ex-post estimation of the policy scenario. The example outlined in Box 7.4 shows how users can determine the building type categories included in the assessment.

[6] Available at: http://episcope.eu/building-typology/overview/

[7] Available at: https://www.eia.gov/consumption/commercial/building-type-definitions.php

Box 7.4: Example of determining the building types to include in the assessment

Buildings sector regulation in Country A typically differentiates between three different residential building types (*existing national classification*):

- Building type A: Single-family house (SFH)
- Building type B: Apartment block (AB)
- Building type C: Multi-family house (MFH)

In addition, the national statistics bureau reports all buildings sector statistics for all of these building type classifications (*data availability*).

The regulatory policy under assessment, however, only addresses two residential building types (*policy relevance*):

- Building type A: Single-family house (SFH)
- Building type B: Apartment block (AB)

Therefore, the user decides to conduct the baseline estimation with these two building types.

Note that this is a simplified example for illustrative purposes and the categories used here might not reflect the reality of building categories in a given country context (e.g., with further differentiation such as Single-family detached, Single-family attached - townhouses, Multifamily - four stories or less, Multifamily - five stories or greater).

7.3.2 Step 2: Determine climate zone differentiation for building types

Determine the climate zones for each of the building types (climate zone$_{(z)}$). Different climate zones in a country may imply substantial differences in heating and cooling degree days between these zones which lead to different heating and cooling demand (e.g., a northern climate zone with lower average temperatures during the year and a southern zone with higher temperatures during the year). Often this affects the type of buildings constructed in a given climate zone.

The concept of heating degree days (HDD) and cooling degree days (CDD) is central to this determination. A degree day compares the mean outdoor temperature recorded for a location to a standard temperature. HDD are a measure of how cold the temperature was on a given day or over a period of days, while CDD are a measure of how warm the temperature was.[8] A degree day provides insight on how warm or cold a region is. The more extreme the outside temperature, the higher the degree days and required energy use for heating or cooling.

Databases for heating and cooling degree days are widely available and often provided by national governments. It is important to identify logical stratification for degree day zones, as the actual changes in degree days are gradual. Where available, users should use pre-defined zonings used by the government (or others) should be used if available. The decision on the number and categorisation of climate zones can be informed by:

[8] US Energy Information Agency 2018

- **Policy relevance**: Users could base their decision on the policy being assessed. When policies differentiate between different climate zones (e.g., different efficiency specifications for certain building types in different climate zones in a building code), users could reflect such specifications according to climate zones in the estimation approach.
- **Existing national classifications**: Users could use existing classifications of climate zones for the country context. For example, the US Office of Energy Efficiency and Renewable Energy provides a classification and definition of different climate zones.[9] This approach might increase coherence with existing regulations in the sector.
- **Data availability**: Users could include different climate zones based on available data. When data on different climate zones is limited, it might be preferable to differentiate among a lower number of climate zones or even none.

Consideration of the above should take into account the desired level of accuracy and the resources available to undertake the assessment. It is important to ensure that climate zones are consistent between the estimation of baseline emissions and the ex-ante and/or ex-post estimation of the policy scenario. If users conduct projections without any further differentiation of climate zones (e.g. due to a lack of available data), users should transparently report such a decision and outline the implication for the projection. The example outlined in Box 7.5 shows how users can determine the climate zones for building types.

Box 7.5: Example - determining climate zone differentiation for building types

Buildings sector regulation in Country A typically differentiates between two climate zones (*existing national classification*):

- **Climate zone C (Hot-Dry)**: Region that receives less than 50cm of annual precipitation, monthly average outdoor temperature remains above 7°C throughout the year and there are few differences between hot and cold days. The zone has on average 1300 HDD and 2450 CDD.
- **Climate zone D (Mixed-Dry)**: Region that receives less than 50cm of annual precipitation, approximately 30 HDD or less, average monthly outdoor temperature drops below 7°C during winter months but also gets very hot in the summer. The zone has an average of 5,400 HDD.

A consultation with national buildings sector experts clarifies that both these climate zones should be accounted for in the assessment in order to achieve a sufficiently high level of accuracy (accuracy of estimation). For this reason, the baseline estimation is conducted with these two climate zones.

7.3.3 Step 3: Estimate number of buildings by building type in each climate zone

Estimate values for the *number of buildings* parameter for each of the three building stock types, by building type$_{(b)}$ in climate zone$_{(z)}$ in year$_{(a)}$ following the guidance provided in Table 7.5. The example outlined in Box 7.6 shows how the guidance can be applied for new buildings.

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[9] Available at: https://energy.gov/eere/buildings/climate-zones

Table 7.5: Estimating value for number of buildings

Approach	Assumptions	Potential data sources
Existing buildings		
1. Use monitored historical values for existing building stock by building type and climate zone, or rely on expert judgment if no data is available 2. Determine baseline demolition rate of existing buildings by climate zone and building type 3. Determine baseline rate of renovation by climate zone and building type (see also below for retrofitted buildings) 4. Determine baseline construction rate of new buildings by climate zone and building type 5. Calculate number of new buildings and subtract annual number of demolished and retrofitted buildings (see also retrofitted buildings below) to estimate baseline number of existing buildings for each year in the assessment	• Assumption(s) on historical level of building stock by climate zone and type (if no historical data are available) • Assumption(s) on baseline rate of demolition by climate zone and building type • Assumption(s) on baseline rate of renovation by climate zone and building type (see also below for retrofitted buildings) • Assumption(s) on baseline rate of construction by climate zone and building type	• National, subnational or municipal statistics bureaus (i.e.,can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) • Related studies in the field • Expert judgment
Retrofitted buildings		
1. Use monitored historical values for existing building stock by climate zone and building type, or rely on expert judgment if no data is available 2. Determine different existing levels of renovation in the country (e.g., shallow and deep retrofit) 3. Determine baseline rate of renovation by climate zone and building type per existing level of renovation 4. Calculate baseline stock of retrofitted buildings by climate zone and building type for each year of assessment	• Assumption(s) on historical level of building stock by climate zone and type (if no historical data are available) • Assumption(s) on existing levels of renovation in the country • Assumption(s) on baseline rate of renovation by climate zone and type	• National, subnational or municipal statistics bureau • Related studies in the field • Expert judgment
New buildings		
1. Use monitored historical values for existing building stock by climate zone and building type, or rely on expert judgment if no data is available 2. Determine baseline demolition rate of existing buildings by climate zone and building type (see also existing buildings above) 3. Determine baseline rate of renovation by climate zone and building type (see also retrofitted buildings above)	• Assumption(s) on historical level of building stock by climate zone and type (if no historical data available) • Assumption(s) on baseline demolition rate of existing buildings by climate zone and type • Assumption(s) on baseline rate of renovation by climate zone and building type (see also retrofitted buildings above)	• National, subnational or municipal statistics bureau • Related studies in the field • Expert judgment

4. Determine baseline construction rate of new buildings by climate zone and type 5. Calculate baseline number of new buildings by climate zone and building type	• Assumption(s) on baseline construction rate of new buildings by climate zone and type	

Box 7.6: Example of estimating number of buildings per building type$_{(b)}$ in climate zone$_{(z)}$ for new buildings

1. *Use monitored historical values for existing building stock by climate zone and building type or rely on expert judgment if no data is available*

   A request for information to the national statistics bureau on the historical values for existing building stock in Country A provides the following information for 2016:

   Building type A in climate zone C: 20.000 buildings

   Building type A in climate zone D: 15.000 buildings

   Building type B in climate zone C: 30.000 buildings

   Building type B in climate zone D: 10.000 buildings

2. *Determine baseline demolition rate of existing buildings by climate zone and type*

   A recent government-funded study on the development of the buildings sector projects the following annual demolition rates up to 2020:

   Building type A in climate zone C: 0.2%

   Building type A in climate zone D: 0.3%

   Building type B in climate zone C: 0.4%

   Building type B in climate zone D: 0.1%

3. *Determine baseline rate of renovation by climate zone and building type*

   For reasons of simplicity a renovation rate of zero has been assumed in the example.

4. *Determine baseline construction rate of new buildings by climate zone and building type*

   A recent government-funded study on the development of the buildings sector forecasts the following annual construction rates up to 2020:

   Building type A in climate zone C: 1%

   Building type A in climate zone D: 3%

   Building type B in climate zone C: 4%

   Building type B in climate zone D: 2%

5. *Calculate number of new buildings and subtract annual number of demolished and retrofitted buildings (see also "retrofitted buildings" below) to estimate baseline number of existing buildings for each year in the assessment*

   Based on the data collected under Steps 1-4, the cumulative number of new buildings can be estimated for each year of the assessment period up to 2020. The calculations are done for the first two years of the assessment period (i.e., 2017 and 2018) for building type A in climate zone C.

2017:

20,000 [existing buildings at beginning of year 2017] * 0.01 [assumed construction rate] = **200 [new buildings in 2017]**

2018:

(20,000 [existing building stock at beginning of year 2017] + 200 [new buildings stock in year 2017]) * (1-0.002) [assumed demolition rate] = 20,160 [existing buildings at end of 2017]

20,160 [existing buildings at beginning of year 2018] * 0.01 [assumed construction rate] = **202 [new buildings in 2018]**

As explained above, for reasons of simplicity a renovation rate of zero has been assumed in the example.

7.3.4 Step 4: Estimate average annual specific energy use per m^2

Estimate baseline values for the *average annual specific energy use per m^2* parameter, by building type$_{(b)}$ in climate zone$_{(z)}$ in year$_{(a)}$ following the guidance provided in Table 7.6. The *average annual specific energy use per m^2* comprises all energy data for end-uses included in scope of this guidance (i.e., space heating and cooling; appliances related to heating, cooling and hot water; and lighting). The same approach is recommended for all three building stock types. The example outlined in Box 7.7 shows how the guidance outlined in Table 7.6 can be applied for new buildings.

Table 7.6: Estimating value for average annual specific energy use per m^2

Approach	Assumptions	Potential data sources
1. Use monitored historical values on *average annual specific energy use per m^2* for existing, retrofitted and/or new buildings by climate zone and building type, or rely on expert judgment if no data is available. 2. Determine autonomous baseline rate[10] of annual efficiency improvement for existing, retrofitted and/or new building stock by climate zone and building type 3. If relevant, differentiate this autonomous baseline rate by different levels of retrofits (e.g., *shallow* and *deep* retrofit) 4. Calculate *average annual specific energy use per m^2* with autonomous baseline rate of annual efficiency improvement for existing, retrofitted and/or new building stock by climate zone and building type	• Assumption(s) on historical values of *average annual specific energy use per m^2* for existing, retrofitted and/or new buildings by climate zone and building type (if no historical data available) • If such assumptions are made it might be useful to base these on "model" houses that can be scaled to the housing stock looked at • Assumption(s) on autonomous baseline rate of annual efficiency improvement for existing, retrofitted and/or new building stock by climate zone and building type • Assumption(s) on autonomous baseline rate of annual efficiency improvement for different types of retrofits	• National, subnational or municipal statistics bureau (can include statistics from surveys like census or household survey)[11], tax or property databases (for building information), energy databases (for building energy use data)) • Related studies in the field • Expert judgment

[10] The autonomous baseline rate is the autonomous efficiency improvement that occurs in the sector even without any additional policies being implemented (e.g., through technological development)

[11] See for example EIA database for commerical buildings at: https://www.eia.gov/consumption/commercial/data/2012/

Box 7.7: Example of estimating average annual specific energy use per m^2 for new buildings

1. *Use monitored historical values on average annual specific energy use per m^2 for new buildings by climate zone and building type, or rely on expert judgment if no data is available*

   A request for information at the national statistics bureau in Country A on *average annual specific energy use per m^2* for new buildings by climate zone and type provides the following information for 2016:

   Building type A in climate zone A: 100 kWh per m^2

   Building type A in climate zone B: 150 kWh per m^2

   Building type B in climate zone A: 90 kWh per m^2

   Building type B in climate zone B: 130 kWh per m^2

   * Note that this data is in not readily available in some countries. In such a case, users need to calculate the average specific energy use based on national statistics on the square footage, the energy use per carrier, etc. This calculation would be too extensive to describe in detail here. National buildings sector experts may need to be consulted to assist this such calculations.

2. *Define autonomous baseline rate of annual efficiency improvement for new buildings by climate zone and building type*

   As the national statistics bureau in Country A does not provide such data, two buildings departments at local universities are consulted to provide estimates on the autonomous baseline rate of annual efficiency improvement for new buildings by climate zone and building type up to 2020. The provided autonomous baseline rate of annual efficiency improvement for new buildings are blended rates (i.e. they include heating/cooling and appliances that are within the scope of the assessment).

   Building type A in climate zone A: 2%

   Building type A in climate zone B: 1.5%

   Building type B in climate zone A: 1%

   Building type B in climate zone B: 0.5%

3. *If relevant, differentiate this autonomous baseline rate by different levels of retrofits (e.g., shallow and deep retrofit)*

   This calculation step is not required for existing buildings.

4. *Calculate average annual specific energy use per m^2 with autonomous baseline rate of annual efficiency improvement for new building stock by climate zone and building type*

   Based on the data collected in Steps 1-3, the *average annual specific energy use per m^2* for new buildings by climate zone and type can be estimated for each year of the assessment period up to 2020. The calculations are done below for the two years of the assessment period (i.e., 2017 and 2018) for building type A in climate zone A, as an example. This calculation should be repeated for every single year of the assessment period using the autonomous baseline rate of annual efficiency improvement.

   2017

   100 kWh per m^2 [*average annual specific energy use per m^2* in 2016] * (1-0.02) [assumed autonomous baseline rate of annual efficiency improvement] = **98 kWh per m^2 [average annual specific energy use per m^2 in 2017]**

2018

98 kWh per m^2 [*average annual specific energy use per m^2* in 2017] * (1-0.02) [assumed autonomous baseline rate of annual efficiency improvement] = **96.04 kWh per m^2 [average annual specific energy use per m^2 in 2018]**

7.3.5 Step 5: Determine the share of each energy carrier in fuel mix

Determine baseline values for the *share of energy carrier in the fuel mix* parameter by building type$_{(b)}$ in climate zone$_{(z)}$ in year$_{(a)}$ following the guidance provided in Table 7.7. The same approach is recommended for all three building stock types. An energy carrier is a transmitter of energy, including electricity and heat as well as solid, liquid and gaseous fuels which occupy intermediate steps in the energy-supply chain between primary sources and end-use applications. The example outlined in Box 7.8 shows how the guidance in Table 7.7 can be applied for new buildings.

Table 7.7: Estimating value for share of energy carrier in fuel mix

Approach	Assumptions	Potential data sources
1. Use monitored historical share of energy carriers in fuel mix, or rely on expert judgment if no data is available 2. Use assumption on development of the share of energy carriers in the fuel mix to estimate energy carrier emission factors for each year of the assessment	• Assumption(s) on historical share of energy carriers in the fuel mix (if no data is available) • Assumption(s) on development of share of energy carriers in the fuel mix	• National, subnational or municipal statistics bureau (can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) [12] • Related studies in the field • Expert judgment

Box 7.8: Example of determining share of energy carrier$_{(f)}$ in the fuel mix for new buildings

1. *Use monitored historical share of energy carriers in fuel mix, or rely on expert judgment if no data is available*

A request for information to the national statistics bureau in Country A on the share of energy carriers in the fuel mix of new buildings provides the following information for 2016. As climate zone C (hot-dry) mainly has a need for cooling, buildings in this climate zone predominantly use HVACs.

Building type A in climate zone C:

- Natural gas: 11%
- Electricity: 89%

Building type A in climate zone D:

- Natural gas: 47%
- Electricity: 53%

Building type B in climate zone C:

- Natural gas: 15%
- Electricity: 85%

[12] See for example EIA database for commerical buildings at: https://www.eia.gov/consumption/commercial/data/2012/

Building type B in climate zone D:

- Natural gas: 45%
- Electricity: 55%

2. *Use assumption on development of share of energy carriers in fuel mix to estimate energy carrier emission factors for each year of the assessment*

   A consultation with local experts with ample experience with Country A's buildings sector provide estimates on the share of energy carriers in the fuel mix of new buildings up to 2020. In the following, the baseline values are presented for two years of the assessment period (2017 and 2018).

   2017:

   Building type A in climate zone C:

   - Natural gas: 10%
   - Electricity: 90%

   Building type A in climate zone D:

   - Natural gas: 46%
   - Electricity: 54%

   Building type B in climate zone C:

   - Natural gas: 14%
   - Electricity: 86%

   Building type B in climate zone D:

   - Natural gas: 45%
   - Electricity: 55%

   2018:

   Building type A in climate zone C:

   - Natural gas: 9%
   - Electricity: 91%

   Building type A in climate zone D:

   - Natural gas: 45%
   - Electricity: 55%

   Building type B in climate zone C:

   - Natural gas: 13%
   - Electricity: 87%

   Building type B in climate zone D:

   - Natural gas: 44%
   - Electricity: 56%

7.3.6 Step 6: Estimate average floor area per building

Estimate baseline values for the *average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$ in year$_{(a)}$,* for each of the three building types following the guidance provided in Table 7.8. The example outlined in Box 7.9 shows how the guidance in Table 7.8 can be applied for new buildings.

Table 7.8: Estimating value for average floor area per building

Approach	Assumptions	Potential data sources
Existing buildings		
1. Use monitored historical values on *average floor area* for existing buildings by climate zone and building type, or rely on expert judgment if no data is available 2. Use assumption on whether composition of type of buildings being demolished or renovated changes *average floor area* of existing buildings stock to estimate *average floor area* for each year of the assessment	• Assumption(s) on historical values of *average floor area* by climate zone and building type (if no data is available) • Assumption(s) on share of buildings being retrofitted/demolished by climate zone and building type	• National, subnational or municipal statistics bureau (can include statistics from census or household surveys, tax or property databases (for building information), energy databases (for building energy use data)) • Related studies and guidance in the field such as International Property Measurement Standards (IPMS) for residential[13] and commercial buildings[14] • Expert judgment
Retrofitted buildings		
1. Use monitored historical values on *average floor area* for renovated buildings by climate zone and type or rely on expert judgment if no data is available 2. Use assumption on how type of retrofits during the years of the assessment affect the *average floor area* to estimate *average floor area* by climate zone and type for each year of the assessment	• Assumption(s) on historical values of *average floor area* for renovated buildings by climate zone and building type (if no data is available) • Assumption(s) on how retrofits affect the average floor area	• National, subnational or municipal statistics bureau • Related studies in the field • Expert judgment
New buildings		
1. Use monitored historical values on *average floor area* for new buildings by climate zone and building type or rely on expert judgment if no data is available 2. Use assumption on baseline determination of average baseline floor area of new buildings by climate zone and building type to estimate average baseline floor area by climate zone and type for each year of the assessment	• Assumption(s) on historical values of *average floor area* for new buildings by climate zone and building type (if no data is available) • Assumption(s) on baseline determination of average baseline floor area of new buildings by climate zone and building type	• National, subnational or municipal statistics bureau • Related studies in the field • Expert judgment

Box 7.9: Example of estimating average floor area per building for new buildings

1. *Use monitored historical values on average floor area for new buildings by climate zone and building type, or rely on expert judgment if no data is available*

   A request for information to the national statistics bureau in Country A on *average floor area per building by building type*$_{(b)}$ for new buildings provides the following information for 2016:

Building type A in climate zone A: 88 m^2 per building

Building type A in climate zone B: 88 m^2 per building

Building type B in climate zone A: 168 m^2 per building

Building type B in climate zone B: 168 m^2 per building

2. *Use assumption on baseline determination of average baseline floor area of new buildings by climate zone and building type to estimate average baseline floor area by climate zone and type for each year of the assessment*

As the national statistics bureau in Country A does not provide such data, two buildings departments at local universities are consulted to provide estimates on baseline growth rate of the average baseline floor area of new buildings by climate zone and type up to 2020:

Building type A in climate zone A: 0.5%

Building type A in climate zone B: 0.5%

Building type B in climate zone A: 1%

Building type B in climate zone B: 1%

Based on the data collected, the *average floor area* per building for new buildings by climate zone and building type can be estimated for each year of the assessment period up to 2020. The calculations are done for the two years of the assessment period (2017 and 2018) for building type A in climate zone A.

2017

88 m^2 per building [*average floor area per building* in 2016] * (1+0.005) [assumed baseline determination of average baseline floor area] = **88.44 m^2 per building [average floor area per building in 2017]**

2018

88.44 kWh per m^2 [*average floor area per building* in 2017] * (1-0.005) [assumed baseline determination of average baseline floor area] = **88.88 m^2 per building [average floor area per building in 2018]**

7.3.7 Step 7: Estimate energy carrier emission factors

Estimate baseline values for the *energy carrier emission factors* parameter following the guidance provided in Table 7.9. The same approach is recommended for all three building types. The example outlined in Box 7.10 shows how the guidance outlined in Table 7.9 can be applied for new buildings.

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[13] Available at: http://www.rics.org/uk/knowledge/professional-guidance/international-standards/ipms-residential-buildings/.

[14] Available at: http://www.rics.org/uk/knowledge/professional-guidance/international-standards/ipms-for-office-buildings/.

Table 7.9: Baseline value estimation for energy carrier emission factors

Approach	Assumptions	Potential data sources
1. Use country statistics of energy carrier emission factors, rely on expert judgment and/or use IPCC guidelines to determine emission factors if no data is available 2. Use assumption on development of energy carrier emission factors to estimate energy carrier emission factors for each year of the assessment. Depending on fuel mix in the sector this should also include indirect energy carriers' types of electricity and heating.	• Assumption(s) on historical energy carrier emission factors (if no data is available) • Assumption(s) on development of energy carrier emission factors. This might require assumptions on efficiency of end use energy provision (e.g., through appliances)	• National, subnational or municipal statistics bureau (statistics can include statistics from surveys (like census or household survey), tax or property databases (for building information), energy databases (for building energy use data)) • Related studies in the field • Expert judgment

Box 7.10: Example of determining energy carrier$_{(f)}$ emission factors for new buildings

1. *Use country statistics of energy carrier emission factors, rely on expert judgment and/or use IPCC guidelines to determine emission factors.*

   A request for information to the national statistics bureau in Country A on the energy carriers$_{\mathbf{(f)}}$ emission factors provides the following information for 2016:

   - Natural gas: 290 gCO_2e/kWh
   - Electricity: 300 gCO_2e/kWh

   For the emission factor for natural gas, the efficiency of the fuel system has to be taken into account in the calculation of the emission factor. Average efficiency of heating systems in the country is currently about 80%. Further consultation with the statistics bureau confirms that this already has been included in the emission factor reported.

2. *Use assumption on development of energy carrier emission factors to estimate energy carrier emission factors for each year of the assessment. Depending on the fuel mix in the sector this should also include indirect energy carriers' types of electricity and heating*

   As the national statistics bureau in Country A does not provide such data, the Ministry of Energy is consulted to provide estimates on assumptions for the development of energy carrier emission factors up to 2020. Based on assumptions on the development of the efficiency of natural gas as well as the fuel mix in the electricity the following annual changes in the emission factor were estimated:

   - Natural gas: 2% reduction per year
   - Electricity: 3% reduction per year

   Based on the data collected, the energy carrier$_{(f)}$ emission factors can be estimated for each year of the assessment period up to 2020. The calculations are done for the two years of the assessment period (2017 and 2018).

2017

- Natural gas: 290 gCO_2e/kWh [emission factor in 2016] * (1-0.02) [assumed rate of improvement] = **284.2 gCO_2e/kWh [emission factor in 2017]**
- Electricity: 300 gCO_2e/kWh [emission factor in 2016] * (1-0.03) [assumed rate of improvement] = **291.0 g CO_2e/kWh [emission factor in 2017]**

2018

- Natural gas: 284.2 gCO_2e/kWh [emission factor in 2016] * (1-0.02) [assumed rate of improvement] = **278.52 gCO_2e/kWh [emission factor in 2018]**
- Electricity: 291.0 gCO_2e/kWh [emission factor in 2016] * (1-0.03) [assumed rate of improvement] = **282.27 gCO_2e/kWh [emission factor in 2018]**

7.3.8 Step 8: Calculate baseline emissions for each year of the assessment period

Using the estimated values for all parameters in Steps 3 - 7, calculate the baseline emissions in the buildings sector for each year of the assessment period using Equation 7.1 (the equation is described in Section 7.2). The example outlined in Box 7.11 shows how to calculate GHG emissions using the estimated values for all parameters in Steps 3 - 6.

Box 7.11: Example of estimating baseline emissions using the calculated baseline values

Baseline emissions are calculated for two years of the assessment period (2017 and 2018). These two years are taken from a longer assessment period for the purposes of simplifying the example.

2017:

Building type A in climate zone C

Baseline emissions in 2017 = **(**200 [new buildings] * 98 kWh per m^2 [average annual specific energy use per m^2] * 49% [share of gas in fuel mix] * 88.44 m^2 per building [average floor area] * 284.20 gCO_2e/kWh [emission factor for gas]**)** + **(**200 [new buildings] * 98 kWh per m^2 [average annual specific energy use per m^2] * 51% [share of electricity in fuel mix] * 88.44 m^2 per building [average floor area] * 291.0 gCO_2e/kWh [emission factor for electricity]**)**

= 503 tCO_2e (baseline emissions from building type A in climate zone C in 2017

Building type A in climate zone D

Baseline emissions in 2017 = **1,692 tCO_2e (baseline emissions from building type A in climate zone D in 2017)**

Building type B in climate zone C

Baseline emissions in 2017 = **17,540 tCO_2e(baseline emissions from building type B in climate zone C in 2017)**

Building type B in climate zone D

Baseline emissions in 2017 = **3,889 tCO_2e(baseline emissions from building type B in climate zone D in 2017)**

Total baseline emissions for all building types in all climate zones in 2017 = **23,625 tCO_2e**

2018:

Building type A in climate zone C

Baseline emissions in 2018 = **(**402 [cumulative new buildings] * 96 kWh per m^2 [average annual specific energy use per m^2] * 48% [share of gas in fuel mix] * 88.88 m^2 per building [average floor area] * 278.52 gCO_2e/kWh [emission factor for gas]**)** + **(**402 [cumulative new buildings] * 96 kWh per m^2 [average annual specific energy use per m^2] * 52% [share of electricity in fuel mix] * 88.88 m^2 per building [average floor area] * 282.27 gCO_2e/kWh [emission factor for electricity]**)**

= 962 tCO_2e(baseline emissions from building type A in climate zone C in 2018

Building type A in climate zone D

Baseline emissions in 2018 = **3,301 tCO_2e (baseline emissions from building type A in climate zone D in 2017)**

Building type B in climate zone C

Baseline emissions in 2018 = **34,388 tCO_2e (baseline emissions from building type B in climate zone C in 2018)**

Building type B in climate zone D

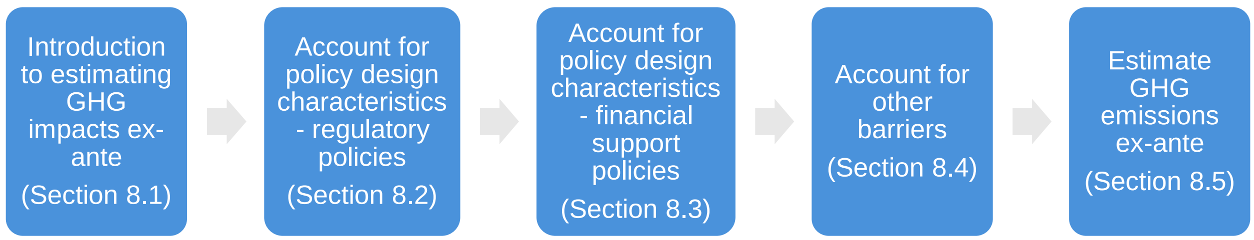
Baseline emissions in 2018 = **7,647 tCO_2e (baseline emissions from building type B in climate zone D in 2018)**

Total baseline emissions for all building types in all climate zones in 2018 = **46,300 tCO_2e**

8. Estimating GHG Impacts Ex-Ante

This chapter describes how to estimate the expected future GHG effects of the policy (ex-ante assessment). Users estimate values for all parameters in the policy scenario and calculate expected GHG emissions for each year of the assessment period. The obtained GHG emissions can either be used to compare the policy scenario emissions level to a sectoral target or to calculate the expected GHG emission reductions achieved by the policy. For the latter, users should estimate baseline emissions following the guidance in Chapter 7.

Figure 8.1: Overview of steps in the chapter



Checklist of key recommendations:

- Estimate the effect of policy design characteristics on each of the estimation parameters for each year of the assessment period
- Identify barriers not addressed by the policy and account for their effect on the relevant estimation parameters for each year of the assessment period
- Estimate the GHG emissions for each year of the assessment period using the ex-ante values for each estimation parameter
- Where the user's objective is to estimate GHG emission reductions expected to be achieved by the policy, estimate the GHG impacts of the policy by subtracting baseline emissions from policy scenario emissions

8.1 Introduction to estimating GHG impacts ex-ante

In order to estimate emissions for the policy, users assess how the policy affects the values of the parameters used for estimating baseline emissions (see Section 7.2). This is done for each year of the assessment period by accounting for policy design characteristics and barriers to the policy. The relevant estimation parameters for estimating ex-ante GHG impacts are:

- *Number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ (integer)*
- *Average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ kWh per m^2)*
- *Share of energy carrier$_{(f)}$ in fuel mix (% of total fuel mix)*
- *Average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$ up to year$_{(a)}$ (m^2 per building)*
- *Energy carrier$_{(f)}$ emission factors (gCO_2e per kWh)*

The general approach of the guidance is to first estimate the expected effect of the policy on each parameter, then to account for barriers to obtain final parameters, then convert this into the actual GHG impacts of the policy. The specific steps and sections to follow depend on the type of policy, or combination of policies, being assessed, as described in Table 8.1.

Table 8.1: Steps and sections to follow for various buildings policies

Type of policy/policies	Steps and sections to follow
Regulatory policy without complementary financial support policy	Estimate expected effect of the policy on the parameter values following guidance for regulatory policies (Section 8.2) Account for other barriers (Section 8.4) Estimate GHG impacts (Section 8.5)
Regulatory policy with complementary financial support policy	Estimate expected effect of the policy on the parameter values following guidance for regulatory policies (Section 8.2) Refine each parameter value by evaluating whether the financial support policy could lead to an impact what could be expected from the regulatory policy alone (Section 8.3) Account for other barriers (Section 8.4) Estimate GHG impacts (Section 8.5)
Standalone financial support policy (i.e., no complementary regulatory policy	Estimate expected effect of the policy on the parameter values following guidance for financial support policies (Section 8.3) Account for other barriers (Section 8.4) Estimate GHG impacts (Section 8.5)

Due to the non-binding nature of voluntary building codes, financial support policies can often be used to determine the impact of the policy. It may therefore be useful to apply an iterative approach when following the guidance in Sections 8.2 and 8.3 (where a voluntary building code and financial support policy are implemented together).

The guidance does not account for spillover effects, whereby for example better building practices mandated by a policy in one region of a country improve practices in other regions. Users could account for these effects using their own approach where sufficient data are available.

8.2 Account for policy design characteristics - regulatory policies

It is a *key recommendation* to estimate the effect of policy design characteristics on each of the estimation parameters for each year of the assessment period. The key estimation parameters effected by regulatory policies are *average annual specific energy use* and *share of energy carrier in fuel*, though the steps below also provide guidance for the other estimation parameters.

8.2.1 Step 1: Identify main design characteristics of the policy

Identification of the main design characteristics of the policy provides users with the information necessary to conduct the ex-ante assessment in the subsequent steps. The identification of specific information, such as whether a building code is set up as a *prescriptive performance building code* or a *performance building code,* is crucially important in estimating the impact of the building code on the different parameters.

Identify design characteristics for the policy using the list provided in Table 8.2 adapting it as needed for the policy context. The table lists the most relevant design characteristics for each of three types of regulatory policies covered by this guidance. Box 8.1 provides an example demonstrating how to identify design characteristics.

Table 8.2: Design characteristics of the most common regulatory policies

Design characteristic	Description
Building codes	
Level of specification	• **Prescriptive performance building code** that sets minimum energy performance requirements for each building component (e.g., permissible levels of heat loss for windows, roofs and walls, and/or efficiency levels for heating, cooling and lighting equipment) • **Performance building code** that requires the overall building to be considered as one single system
Building component included (only for prescriptive building code)	• Building components included in the prescriptive performance building code
Minimum energy performance requirements for each building component (only for prescriptive building code)	• Permissible levels of heat loss for windows, roofs and walls • Efficiency levels for heating, cooling and lighting equipment
Target building end-use	• Target building end-use: public, residential and commercial
Focus of code	• Retrofit of existing building stock • Construction of new building stock
Geographical scope of building code	• Geographical scope (national, subnational) to which the building code applies
Spatial and technical level of variation	• Minimum requirements and technical specifications according to climate zone
Systematic code revision	• Systematic process to revise code to continually raise ambition over time
Compliance requirement	• Voluntary, mandatory or mixed implementation
Aligned energy sufficiency measures	• Non-technological solutions related to the design of a building and its daily management and operation
Specification on (required) use of renewable energy sources	• (Obligatory) specifications on use of renewable energy sources (e.g., biomass and district heating systems) when technically feasible and economically viable
Type of legislation	• Requirements on building codes • Requirements set in legislation specifically concerning the energy efficiency of buildings
Integrated label requirement	• Building code requires labelling of buildings

Integrated information policies	• Building code specifies information instruments to ensure communication of code requirements
Enforcement specifications	• Building code defines certain enforcement specifications
Appliance standards	
(Minimum) eco-design requirements	• Minimum energy performance requirements
Scope and stringency	• Specification on which appliances/product groups the appliance standard applies to
Systematic code revision	• Systematic process to revise standard to continuously raise ambition over time (for example, based on systematic market monitoring programme)
Integrated label requirement	• Standard requires labelling of appliances
Compliance requirement	• Voluntary, mandatory or mixed implementation
Focus of appliance standard	• Standard directed at manufacture, import, sale, or installations-based
Geographical differentiation	• Different standard levels are defined for different climatic regions (especially for installation-based policies)
Mandatory labelling, certification and energy audits	
Scope	• Existing building stock • New building stock
Target building category	Choice of target building category • Public • Residential • Commercial
Choice of method	• Asset rating (based on data derived from building inspection or drawings and building specifications) or operational rating (metered data of actual energy consumption) • Measured or calculated rating • Basis assessment or detailed assessment
Compliance requirement	• Voluntary, mandatory or mixed implementation
Geographical scope	• Geographical scope to which the energy performance certificate and equipment label applies to
Quality assurance	• Regulation on training, accreditation and certification of experts
Enforcement specifications	• Regulation on enforcement specification such as penalties for issuing incorrect EPCs

Source: Adapted from Laustsen, 2008; Schüwer et al., 2012; IEA, s2010; IEA, 2011; IEA, 2013a; GBPN, 2014; BPIE, 2010; Dungen and Carrington, 2011; Michel et al, 2012; Nogueira, 2013; BPN, 2014

Box 8.1: Example of identifying main design characteristics of regulatory policies

The policy design characteristics for the mandatory building code for new buildings in the residential buildings sector are as follows:

- **Level of specification:** Performance building code that requires the overall building to be considered as one single system
- **Target building category**: Residential buildings sector with building type A (single-family house - SFH) and building type B (apartment block - AB)
- **Focus of code**: Construction of new buildings in the residential buildings sector
- **Geographical scope**: National level with two geographical zone delineated by the different climates: Climate zone C (hot-dry) and Climate zone D (mixed-dry)
- **Spatial and technical level of variation**: Separate specification of performance building code according to building type and climate zone
- **Systematic code revision**: None
- **Compliance requirement**: Mandatory
- **Aligned energy sufficiency measures**: None
- **Specification on (required) use of renewable energy sources**: None
- **Type of legislation**: Requirements in building codes
- **Integrated label requirement**: Pre-existing energy performance labelling scheme (A – best, F – worst)
- **Integrated information policies**:
  - Federal ministry fully informs all building supervisory authorities and provides additional training for staff responsible for introducing the building code at the subnational level
  - Each building supervisory authority serves as a contact point for interested parties (e.g., project developers and architects) in order to provide additional explanation and information
- **Enforcement specifications**: Code Enforcement Sections (CES) established building supervisory authority that are responsible to overview code enforcement

The policy design characteristics for the mandatory minimum energy performance standards for ACs are as follows:

- **(Minimum) eco-design requirements**: Minimum energy performance standards for all new air conditioning installations (same across all geographical regions)
- **Scope and stringency**: All new air conditioning installations for residential use installed from 2017 onwards
- **Systematic code revision**: None

- **Integrated label requirement**: Pre-existing energy performance labelling scheme (A – best, F – worst)
- **Compliance requirement**: Mandatory

8.2.2 Step 2: Evaluate likelihood that each parameter is affected by the policy

Evaluate the likelihood that the estimation parameters for each building stock type are affected by the policy, and the relative magnitude of the expected effects. Conduct this assessment based on the information on policy design characteristics collected in Step 1. Describe the likelihood and relative magnitude in qualitative terms. This should be done for all the relevant estimation parameters.

The result from Step 2 is a preliminary indication of whether and how the policy affects the various estimation parameters. Table 8.3 provides examples of how users can evaluate the likelihood and relative magnitude of regulatory policies on the estimation parameters.

Box 8.2 provides an example of evaluating likelihood and magnitude.

Table 8.3: Example of identification and evaluation of the effect of regulatory policies on estimation parameters

Parameter	Policy	Likelihood (Very likely, Likely, Unlikely)	Relative magnitude (Minor, Moderate, Major)
Average annual specific energy use per m2 by building type(b) in climate zone(z)	Mandatory building code	Very likely	Major
	Voluntary appliance standard for AC	Likely	Moderate
	Voluntary labelling scheme	Unlikely	Minor

Box 8.2: Example of evaluating the likelihood and magnitude

The experts in the Ministry of Building and Housing of Country A conduct a qualitative evaluation of the likelihood and magnitude that each parameter is affected by two regulatory policies (*mandatory building code for new buildings* and mandatory *MEPS for ACs*) taking the design characteristics identified in Step 1 into consideration.

The qualitative analysis summarised in the table below reveals that both policies only affect the key parameter, the *average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$.* In addition, the mandatory building code affects the *number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$*. The policies do not affect the other parameters.

Parameter	Policy	Likelihood (Very likely, Likely, Unlikely)	Relative magnitude (Minor, Moderate, Major)
Number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$	Mandatory building code	**Likely** – Performance requirements of mandatory building code lead to substantial increase in construction costs that reduces the number of newly constructed buildings	**Minor** – The increase in construction costs is estimated to lead only to a minor reduction of the overall number of buildings

	Mandatory MEPS for ACs	**Unlikely** – Performance requirements of mandatory MEPS do not affect number of newly constructed buildings	[-]
Average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$	Mandatory building code	**Very likely** – Performance requirements are mandatory and require a significant reduction of annual energy use below current average of new buildings	**Major** – Performance requirements of mandatory building code require a significant reduction of annual energy use below current average of new buildings
	Mandatory MEPS for ACs	**Likely** – Performance requirements of mandatory MEPS are mandatory and require a significant reduction of energy use of new ACs in new buildings	**Moderate** – As ACs are only one component contributing to the average annual specific energy use per m^2, the mandatory standard is assumed to have moderate effect
Share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$	Mandatory building code	**Likely** – Performance requirements are mandatory and will likely lead to a change in the fuel mix	**Moderate** – As the building code does not require use of renewable energy sources, only a moderate effect is expected. Only the most stringent level of the code will likely lead to as switch to heat pumps
	Mandatory MEPS for ACs	**Unlikely** – Performance requirements of mandatory MEPS most likely do not (or only insignificantly) affect fuel mix	[-]
Average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$	Mandatory building code	**Unlikely** – Performance requirements of mandatory building code do not significantly affect *average floor area* of newly constructed buildings	[-]
	Mandatory MEPS for ACs	**Unlikely** – Performance requirements of mandatory MEPS do not affect *average floor area* of newly constructed buildings	[-]
Energy carrier$_{(f)}$ emission factors	Mandatory building code	**Unlikely** – Performance requirements of mandatory building code do not affect energy carrier emission factors	[-]
	Mandatory MEPS for ACs	**Unlikely** – Performance requirements of mandatory MEPS do not affect energy carrier emission factors	[-]

8.2.3 Step 3: Identify the interaction between different policies (if relevant)

Where a package of policies is being assessed, qualitatively assess overlapping and reinforcing effects between these different policies. A useful tool for this is a policy interaction matrix. An example of a policy interaction matrix is provided in Table 8.4, for users to adapt as needed.

Table 8.4: Example of policy interaction matrix

	Mandatory building code	**Voluntary appliance standard for AC**	**Voluntary labelling scheme**
Mandatory building code	n/a		
Voluntary appliance standard for AC	Overlapping (moderate)	n/a	
Voluntary labelling scheme	Reinforcing (minor)	Independent	n/a

Users should qualitatively describe the interaction between different policies in the respective interaction category (*Independent*, *overlapping*, *reinforcing*, *overlapping and reinforcing*) as defined in Section 5.2.1. Where the policies being assessed overlap and/or reinforce each other, account for these effects under Step 4.

Box 8.3 provides a simplified and illustrative example of how to identify the interaction between different policies. A more complex interaction would be that of a building code and an AC standard on HVAC system sizing. Better building envelopes allow for the installation smaller HVAC systems, which helps offset the additional construction costs associated with the building code. Such an interaction may require careful analysis due to the different lifetimes of building envelopes versus AC systems.

Box 8.3: Example - identifying interactions between different policies

The experts in the Ministry of Building and Housing of Country A evaluate whether the newly introduced policies (*mandatory building code for new buildings* and *mandatory MEPS for ACs*) have overlapping and/or reinforcing effects. The qualitative analysis summarised in the table below reveals that the mandatory building code for new buildings and the mandatory MEPS for ACs are overlapping but do not reinforce each other. The overlap between the two policies on the average specific energy consumption is due to the fact that the energy efficiency improvements of mandatory appliance standards for air conditioning in new buildings are already included in the performance building code for new buildings. This overlap has to be considered when estimating the parameter values in Step 4.

	Mandatory building code	**Mandatory MEPS for ACs**
Mandatory building code	n/a	
Mandatory MEPS for ACs	Overlapping (full) Energy efficiency improvements from mandatory appliance standards for air conditioning in new buildings are already included in the performance building code for new buildings	n/a

8.2.4 Step 4: Estimate magnitude of effect on key estimation parameters

The key estimation parameters that are effected by regulatory policies are the *average annual specific energy use* and *share of energy carrier in fuel mix*. In most cases, regulatory policies affect other parameters to a lesser degree in most cases. Estimate the magnitude of the effect of the policy design characteristics on these two parameters.

Where overlapping and/or reinforcing policies are identified in Step 3, these effects should be accounted for to avoid over or underestimating the parameter value. Where the policy does not affect either of the two estimation parameters, use baseline values estimated in Chapter 7.

Average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$

Building codes

Different types of building codes specify the average annual specific energy use in different ways (e.g., per m^2 or per total building):

- **Prescriptive building codes:** Estimate how minimum energy performance requirements for each building component (e.g., walls, windows, heating and cooling systems) included in the code define the overall average annual specific energy use (either per m^2 or total building). This requires separate calculations to determine the overall impact on the building envelope. Since the performance of one component influences that of the others (e.g., an increase in wall insulation results in a downsizing of heating systems), the impact of single components cannot be calculated separately. Instead they should be calculated in an integrated manner. Where building codes change the minimum energy performance requirements for each building component over time (e.g., stepwise increase in efficiency requirements), this calculation should be done for each year of the assessment period.

Users should specify how the respective building code defines the average annual specific energy use over time, such as for each year of the assessment period. Based on Rohde (2017), the following general formula for the primary energy demand of buildings can be used for this estimation:

$$Q_p = f_p * Q_{fuel} = f_p * (Q_{trans} + Q_{vent} + Q_{water} - \eta * Q_{gains} + Q_{supply})$$

Where:

Q_p = Primary energy demand

f_p = Primary energy factor

Q_{trans} = Transmission heat demand

Q_{vent} = Ventilation losses

Q_{water} = Hot water demand

Q_{gains} = Solar and internal gains

Q_{supply} = Technical losses of supply system

As explained above, prescriptive performance building codes specify minimum energy performance requirements for a number of different building components, which affect the primary energy demand for one or more of the different components in the formula above (i.e., Q_{trans}, Q_{vent}, Q_{water}, Q_{gains}, and/or Q_{supply}). Depending on building components for which the prescriptive performance building code specifies the minimum energy performance requirements, the effect on the primary energy demand (i.e., the average annual specific energy use per m^2) should be calculated. For this, users can refer to the I*SO 13790:2008 Calculation of energy use for space heating and cooling*[15] and *ISO 16343:2013 Methods for expressing energy performance and for energy certification of buildings*[16]. As the calculation of different minimum energy performance requirements for different components into the *average annual specific energy use per m^2* is rather technical and complicated depending on the number of components addressed, users might want to consult technical experts for this exercise.

Project developers have to account for the specifications that are set for the minimum energy performance requirements for different components by switching energy carriers (affecting f_p), insulating the building shelf (affecting Q_{trans}), replacing of windows/doors (affecting Q_{trans}), or changing the heating system (Q_{supply}).

- **Performance building codes:** Identify how the building codes specify the average annual specific energy use, either per m^2 or per the total building. This information should be provided in the building code. Where building codes change the average annual specific energy use over

[15] Available at: https://www.iso.org/standard/41974.html

[16] Available at: https://www.iso.org/standard/56224.html

time (e.g., a stepwise increase in efficiency requirements), such changes should be accounted for in each year of the assessment period.

Users should be aware that building codes vary across different countries and/or regions. Thus, certain country-specific components or definitions might need to be considered when estimating the average annual specific energy use.

Box 8.4 shows how users can identify the average annual specific energy use, either per m^2 or per the total building.

Box 8.4: Example of identifying the average annual specific energy use

The mandatory performance building code in residential buildings sector for all new buildings developed from 2017 onward specifies the average annual specific energy use per building type for the two different building types (A and B) in the two different climate zones (C and D) for two different periods, namely 2018-2025 and from 2025 onwards:

2017-2025

Building type A in climate zone C: 7,500 kWh/building per year

Building type A in climate zone D: 13,000 kWh/building per year

Building type B in climate zone C: 45,000 kWh/building per year

Building type B in climate zone D: 64,000 kWh/building per year

From 2025 onward

Building type A in climate zone C: 6,500 kWh/building per year

Building type A in climate zone D: 12,000 kWh/building per year

Building type B in climate zone C: 43,000 kWh/building per year

Building type B in climate zone D: 61,000 kWh/building per year

As the assessment period for the ex-ante assessment only spans from 2017 to 2018, only the former efficiency specifications are relevant for the assessment.

Contrary to the estimation of baseline emissions in Step 4 and Step 6 in Section 0, the ex-ante estimation directly uses the average annual specific energy use per building by $\text{type}_{(b)}$ in climate $\text{zone}_{(z)}$ (without specifying energy use per m^2 and then multiplying it with the *average floor area per building by building type*).

Minimum energy performance standards for appliances

There are different types of minimum energy performance standards for appliances that specify the energy performance of appliances for heating, cooling, hot water and lighting. Use the energy performance standards specified in the MEPS to calculate how they impact the average annual specific energy use (per m^2 or per total building) in each year of the assessment.

Where a building code has been implemented in parallel, either include the MEPS in the calculations already undertaken for the building codes (see above for *prescriptive performance building codes*) or make assumptions on how the MEPS influences the building envelope use (see above for *performance* *building codes*). For this purpose, users make assumptions on how certain appliances contribute to the average annual specific energy use for each year of the assessment period. Such assumptions can be based on historical developments projected into the future, relevant studies in the field, or expert judgment. The assumptions should account for country-specific characteristics and trends.

Box 8.5 shows how users can identify the average annual specific energy use, either per m^2 or per the total building, for MEPS of appliances.

Box 8.5: Example of identifying the average annual specific energy use for MEPS of appliances

The mandatory MEPS for ACs specifies the efficiency performance for all new ACs sold from 2017 onward. In the first phase, the performance standard is set for the period between 2017 and 2022.

AC Type 1: 5,400 Btu/hr

AC Type 2: 6,000 Btu/hr

AC Type 3: 7,000 Btu/hr

The previous analysis in Step 3 reveals that the policies being assessed (i.e., the mandatory building code and the MEPS for ACs) fully overlap for new residential buildings, as the building code includes the efficiency improvements of ACs. For this reason, the average annual specific energy use identified from the building code in the previous steps does not have to be adapted.

Mandatory labelling, certification and energy audits

Different types of mandatory labelling, certification and energy audits specify the average annual specific energy use either per m^2 or per total building. Identify how the respective label, certification instrument or energy audit system defines the average annual specific energy use for each year of the assessment period.

Depending on the set-up of these policies, a main obstacle with mandatory labelling, certification and energy audits policies is their non-binding nature, as their impacts depend heavily on the behaviour of the informed consumer. For example, the impact of mandatory labelling for all residential houses might affect the consumers' behaviour differently in different countries and/or regions. To estimate the impact, it is therefore important to understand how the label changes the behaviour of the consumer. Ideally this is done using historical ex-post assessment. If ex-post assessment is not feasible, the user should base the estimate on transparently documented assumptions about the relationship between the instrument and its impact.

Share of energy carrier$_{(f)}$ in fuel mix by type$_{(b)}$ in climate zone$_{(z)}$

Estimate the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$* for each year of the assessment period. Whether and how regulatory policies impact the share of energy carriers in the fuel mix depends on the policy design characteristics, such as whether the implemented policies result in a change of the fuel mix for different building types.

This is generally the case for mandatory building codes that either require a direct change in the fuel mix (e.g., through specifications on required use of renewable energy sources) or indirect change in the fuel mix due to ambitious efficiency requirements for new or retrofitted buildings. Minimum energy performance standards for appliances can alter the fuel mix by significantly reducing the specific energy input for the respective appliances (e.g., use of electricity for ACs or gas for hot water boilers). Such a reduction in the consumption of one energy carrier changes the fuel mix in the buildings sector.

To estimate the effect of the policy design characteristics on the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$,* follow the guidance below:

1. If available, determine the historically monitored fuel mix for different buildings (as explained in Chapter 0 to estimate the baseline values for the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$*).
2. Identify whether the policy specifies a certain share of energy carriers as a mandatory requirement (e.g., through specifications on required use of renewable energy sources or the use of certain technologies such as heat pumps that imply a direct change in the fuel mix). These specifications have to be translated into assumptions on how the share of energy carriers in the fuel mix is affected.
3. If the regulatory policy does not contain such specifications as outlined in the previous step, make an informed decision on how the overall energy efficiency requirements change the fuel mix of different energy carriers.
    a. For **building codes**, the required energy performance of buildings (performance building code) or the combined energy performance of different components of buildings (prescriptive building code) have to be translated into the most likely impact on the fuel mix of energy carriers.
    b. For **MEPS for appliances**, the average reduction of the respective energy input to the appliance due to the energy efficiency improvement has to be expressed in terms of the change in this energy carrier in a household's total consumption. If a MEPS for ACs leads to a 5% reduction of electricity used for cooling, the impact on the change in the fuel mix can be calculated based on the overall share of electricity in the total fuel mix of a building (e.g., 30% electricity, 40% natural gas, 30% oil) as well as the share of electricity used for ACs in a building (e.g., 40% for ACs, 60% for other appliances).
    c. For **mandatory labelling, certification and energy audits**, the non-binding nature of these policies again constitutes a main obstacle as their impacts depend heavily on the behaviour of the informed consumer. For example, the impact of mandatory labelling for all residential houses might affect consumers' behaviour differently depending on the country or region. Thus, different choices are made on whether and how to adapt the building's overall efficiency performance, which then directly affects the fuel mix. To estimate the impact, it is therefore important to understand how such policies change the behaviour of the end consumer. Ideally this is done using historical ex-post assessment. If an ex-post assessment is not feasible, the user should base the estimate on transparently documented assumptions about the relationship between the instrument and its impact.

Box 8.6 shows how users can identify the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$.*

Box 8.6: Identifying the share of energy carrier(f) in fuel mix by building type(b) in climate zone(z)

To determine the impact of the mandatory building code and MEPS for ACs on the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$,* the historically monitored values for shares of energy carriers in the fuel mix for new buildings are identified for 2016 in a first step (similar to Step 7 of Section 0):

2016 (historically monitored values)

Building type A in climate zone C:

- Natural gas: 11%
- Electricity: 89%

Building type A in climate zone D:

- Natural gas: 47%
- Electricity: 53%

Building type B in climate zone C:

- Natural gas: 15%
- Electricity: 85%

Building type B in climate zone D:

- Natural gas: 45%
- Electricity: 55%

In a second step, the policies are assessed as to whether they include specific requirements regarding the choice of fuels:

- The mandatory building code does not specify a certain mix/choice of fuels, only mandatory average annual specific energy use per building type
- The MEPS for ACs only specifies the efficiency level of ACs, hence does not specify a certain mix/choice of fuels per building type.

Therefore, informed assumptions on the effect of the mandatory efficiency requirements stipulated in the building code as well as the efficiency requirements for ACs in the MEPS on the future change in the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$* have to be made. After the consultation with two experts with appropriate experience with Country A's building and construction sector, the following shares are determined – generally leading to a shift from natural gas to electricity for all building types. The reason for this shift is that several beneficiaries decide to switch to using geothermal heat pumps as this becomes more feasible due to the reduced energy use.

2017

Building type A in climate zone C:

- Natural gas: 9%
- Electricity: 91%

Building type A in climate zone D:

- Natural gas: 45%
- Electricity: 55%

Building type B in climate zone C:

- Natural gas: 13%
- Electricity: 87%

Building type B in climate zone D:

- Natural gas: 44%
- Electricity: 46%

2018

Building type A in climate zone C:

- Natural gas: 8%
- Electricity: 92%

Building type A in climate zone D:

- Natural gas: 44%
- Electricity: 56%

Building type B in climate zone C:

- Natural gas: 12%
- Electricity: 88%

Building type B in climate zone D:

- Natural gas: 43%
- Electricity: 57%

8.2.5 Step 5: Estimate magnitude of other estimation parameters (if relevant)

Estimate the magnitude of the effect of the policy design characteristics on the other estimation parameters (i.e., those other than *average annual specific energy use* and *share of energy carrier in fuel mix*).

Where overlapping and/or reinforcing policies are identified in Step 3, these effects should be accounted for to avoid over or underestimating the parameter value. Where the policy does not affect a given estimation parameter, use baseline values estimated in Chapter 7.

Table 8.5 describes how the other estimation parameters may be affected by regulatory policies.

Box 8.7 shows how users can estimate the other parameters where necessary.

Table 8.5: Potential influence of regulatory policies on other parameters

Parameter	Potential influence of regulatory policies on parameters
Number of buildings per type(b) in climate zone(z)	Where ambitious regulatory policies significantly increase construction costs of new building stock, the construction rate of new buildings might decrease. This decrease in the growth rate lowers the number of new buildings constructed per year. Where ambitious policies significantly increase costs of retrofits, the rate of renovation might decrease. This might also affect the rate of demolition of existing building stock. Users should be aware of such effects and account for them where necessary.
Average floor area per building by building type(b) in climate zone(z)	Where ambitious regulatory policies significantly increase construction costs of new building stock, project developers might potentially opt to: • Reduce the total floor area of new buildings to reduce construction costs • Increase the total floor area of new buildings, as future costs for heating and cooling will significantly decrease due to high efficiency standards (rebound effect) Users should be aware of such effects in their countries and account for them where necessary.
Energy carrier(f) emission factors	In general, regulatory policies should not impact energy carrier emission factors. However, users should account for any circumstances in which regulatory policies do so.

Box 8.7: Example of estimating other parameters

Based on the analysis done in Step 3 in Section 8.2.3, only the *number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$* is affected by one of the regulatory policies, namely the mandatory building code. This is due to the fact that the mandatory efficiency requirements in the building code increase construction costs for project developers and thus reduce the number of newly constructed houses.

A consultation with two experts on construction and residential buildings architecture results in the following estimates of how much the average construction costs per building type in each climate zone might increase due to the implementation of the building code:

Building type A in climate zone C: by ~ 6%

Building type A in climate zone D: by ~ 8%

Building type B in climate zone C: by ~ 6%

Building type B in climate zone D: by ~ 7%

The experts estimate that this reduced the growth of buildings as follows:

Building type A in climate zone C: by 5% per year

Building type A in climate zone D: by 7% per year

Building type B in climate zone C: by 3% per year

Building type B in climate zone D: by 2% per year

Using the baseline values for *number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$* estimated in Step 3 in Section 7.3.3, the calculations are done for building type A in climate zone C for the two years of the assessment period (2017 and 2018).

2017:

20,000 [existing buildings at beginning of year 2017] * 0.01 [assumed construction rate] * (1-0.05) [assumed negative impact due to increase in construction costs] = **190 [new buildings in 2017]**

2018:

(20,000 [existing building stock at beginning of year 2017] + 190 [new buildings stock in year 2017]) * (1-0.001) [assumed demolition rate] = 20,190 [existing buildings at end of 2017]

20,190 [existing buildings at beginning of year 2018] * 0.01 [assumed construction rate] * (1-0.05) [assumed negative impact due to increase in construction costs] = **192 [new buildings in 2018]**

8.3 Account for policy design characteristics - financial support policies

It is a *key recommendation* to estimate the effect of policy design characteristics on each of the estimation parameters for each year of the assessment period. The key estimation parameters effected by financial support policies are *number of building (households)*, *average annual specific energy use* and *share of energy carrier in fuel mix*, though the steps below also provide guidance for the other estimation parameters.

8.3.1 General considerations for estimating the effects of financial support policies

The assessment of financial support policies ex-ante can be challenging. Financial support policies provide a price signal but do not provide certainty as to their diffusion or impact. Their diffusion depends heavily on the behavioural changes they are able to induce. These can vary largely in country contexts and depend on a number of factors that cannot be easily quantified (e.g., cultural habits or risk aversion). Consequently, there is no simple way of estimating the diffusion rate of the policy and its resulting impact.

Learning from experience has proven to be the only sufficiently accurate way to achieve this. This means that users should try to obtain ex-post monitored data on the diffusion rate a particular financial support policy has resulted in. If the financial support policy mechanism is new in the country and no experience with it exists, the user should try to obtain expert judgments and/or experience in other country contexts. It is important that this approach is only applied in the beginning. Users should then slowly transfer to using ex-post monitored data as experience with the financial support policy progresses.

Two different estimation approaches are described below, the first outlining estimation of the diffusion rate based on ex-post monitored results and the second approach based on experience in countries.

Approach 1: Estimation of the diffusion rate based on ex-post monitored results of previously implemented policies

This approach is preferred and more accurate. Where possible, users should base their diffusion rate and/or impact estimation of financial support policies on ex-post monitored results of previously implemented financial support policies and their diffusion rate (e.g., number of preferential loans granted).

In an ideal case, the financial support policy has already been implemented for a number of years and data exists on the relationship between the price level and its diffusion rate. However, if this is not the case, experience with similar financial mechanisms or policies implemented in the country can be used. For example, a country might have had a tax incentive for a period of time but then decided to switch to a preferential loan scheme, which is the focus of this analysis.

The feasibility of transferring learning from one policy to another should be carefully checked on a case-by-case basis. In particular, the main design factors, such as total funding rates, technologies covered or information diffusion about the policy, need to be comparable to allow such transfer. Research has found that the uptake of financial policies in one country cannot be easily transferred to another.

Approach 2: Estimation based on transparent analysis of all relevant aspects, preferably based on experience and good guesses by experts in the field

Where an estimation based on ex-post monitored results is not possible, users can base their calculations on informed assumptions around the key aspects. These can then be used to estimate the uptake and effectiveness of the financial support policy. In general, an understanding of the entire complexity at play here requires ample experience in the sector in the country. It is therefore highly advisable to ensure that the experts involved have such knowledge, as otherwise these “good guesses” will have little value.

These assumptions on the most relevant aspects should be well documented and justified. In a limited number of cases, international studies or experience in other countries with similar characteristics, or previous experience with financial support policies in other sectors can also be used to inform and justify the assumptions made.

Use of uncertainty ranges

As estimating the effect of financial support policies is extremely challenging as outlined above, users should opt to use ranges instead of single values to account for the degree of uncertainty with which a policy affects a certain parameter. As the knowledge of how a policy diffuses in a country increases, these uncertainty ranges can become narrower, reflecting a learning process due to more experience and a better understanding of the dynamics. In any case, it is highly advisable to use uncertainty ranges in cases where there is no ex-post monitored data available.

8.3.2 Step 1: Identify main design characteristics of the policy

The identification of the main design characteristics of the policy provides users with the necessary information to conduct the ex-ante assessment in the subsequent steps. For example, it is important to be aware of the eligibility of tax reductions for renovation measures because it affects the number of buildings being renovated.

Identify design characteristics for the financial support policy using the list provided in Table 8.6, adapting it as needed for the policy context. The table lists the most relevant design characteristics for each of the two main financial support policies (financial support policies and fiscal measures) covered by this guidance. Box 8.8 shows how users can identify the main design characteristics for each financial support policy.

Table 8.6: Design characteristics of most common financial support policies

Design characteristics	Description
Financial incentives	
Type of financial incentive	Type of financial support policies such as: • Grants • Subsidies • Preferential loans (e.g., energy-efficient mortgages, which give borrowers the opportunity to finance energy-saving measures as part of a single mortgage)
Level of financial incentive	The level of a financial incentive can be expressed in different ways, for example as an interest rate or an amount granted. For grants it is advisable to use specific figures and not absolute numbers (e.g., USD/m²). For preferential loans it is also advisable to provide market interest rate(s) for reference.
Eligibility	Specifications on persons, households, and/or entities eligible to receive financial incentive
Scope of application	Specifications on scope of applications, such as: • Appliances • energy efficiency investments for retrofit • energy efficiency investments in newly built buildings stock
Energy efficiency requirements	The granting and level of financial incentives might depend on specific achievements in energy efficiency (e.g., level of incentive depending on efficiency label of building after retrofit)
Combination with training, awareness and information programmes	Financial support policies can be coupled with training, awareness and information programmes, which might contribute to a more lasting impact of the financial incentives offered
Coupling with other financial support policies	Financial support policies can be coupled with other financial measures or other financial support policies[17]
Fiscal measures	
Type of tax incentive	Types of fiscal measure, such as: • Tax reductions (reduced/complete tax exemption or refunds) • Tax credits or rebates • Reduced VAT rates • Deductibles
Level of tax incentive	The level of a tax incentive can be expressed in different ways depending on the type. It might also be differentiated by further criteria.

[17] For example, the German development bank KfW launched a set of preferential loans to finance energy efficiency projects through a two-pronged mechanism: public tax exemption for all money invested in efficiency projects coupled with direct public incentives (i.e., preferential loans). Available at: http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-396-06.pdf

Eligibility	Specifications on persons, households and/or entities eligible for the fiscal measure
Scope of application	Specifications on scope of applications, such as: • Appliances • energy efficiency investments for retrofit • energy efficiency investments in newly built buildings stock
Requirements on energy efficiency	The granting and amount of the financial measures might depend on specific achievements in energy efficiency (e.g., level of tax exemption depending on efficiency label of building after retrofit)
Coupling with other financial support policies	Financial policy can be coupled with other financial incentive or other financial support policies

Source: Adapted from Atanasiu et al., 2014.

Box 8.8: Example of identifying main design characteristics of financial support policies

Preferential loan

- **Type of financial incentive**: Preferential loan for energy-efficient construction of new buildings
- **Level of financial incentive**: Reduced interest rate linked to targeted level of efficiency of new building (three different classes of energy-efficiency proposed with three different interest rates)
- **Eligibility**: All project developers of single-family houses
- **Scope of application**: Energy-efficient construction of new single-family houses
- **Energy efficiency requirements**: Two different levels of energy-efficiency requirements (both are more ambitious than the introduced building code)
- **Combination with training, awareness and information programmes**: Public information campaign to inform eligible project developers about financing opportunity
- **Coupling with other financial support policies**: Tax rebate (see below)

Tax rebate

- **Type of tax incentive**: Tax rebate
- **Level of tax incentive**: Tax rebate of up to USD 10,000 at end of fiscal year depending on level of efficiency standard to be implemented
- **Eligibility**: All project developers of single-family houses
- **Scope of application**: Energy-efficient construction of new single-family houses
- **Requirements on energy efficiency**: Two different levels of energy efficiency requirements (both are more ambitious than the introduced building code)
- **Coupling with other financial support policies**: Preferential loan (see above)

8.3.3 Step 2: Evaluate likelihood that each parameter is affected by the policy

Evaluate the likelihood that the estimation parameters for each building stock type are affected by the policy, and the relative magnitude of the expected effects. Conduct this assessment based on the information on policy design characteristics collected in Step 1. Describe the likelihood and relative magnitude in qualitative terms. This should be done for all the relevant estimation parameters.

The result from this Step 2 is a preliminary indication of whether and how the policy affects the various estimation parameters. Table 8.7 provides examples of how users can evaluate the likelihood and relative magnitude of financial support policies on the estimation parameters.

Box 8.9 provides an example of evaluating likelihood and magnitude.

Table 8.7: Identification and evaluation of the effect of financial support policies on estimation parameters

Parameter	**Policy**	**Likelihood** *(Very likely, Likely, Possible, Unlikely, Very unlikely)*	**Relative magnitude** *(Minor, Moderate, Major)*
Average annual specific energy use per m² per building by type$_{(b)}$ in climate zone$_{(z)}$	Preferential loan for deep retrofit	Very likely	Moderate
	Preferential loan for construction of new building	Unlikely	Minor
	Tax rebate for deep retrofit	Likely	Moderate

Box 8.9: Example of evaluating the likelihood and magnitude

The experts in the Ministry of Building and Housing of Country A conduct a qualitative evaluation on the likelihood and magnitude that each parameter is affected by both of the financial support policies (i.e., *preferential loan* and *tax rebate)* taking the design characteristics identified in Section 8.2 into consideration.

The qualitative analysis summarised in the table below reveals that both financial support policies affect the number of buildings per building type$_{(b)}$ in climate zone$_{(z)}$, the *average annual specific energy use per m² by building type$_{(b)}$ in climate zone$_{(z)}$* and the *share of energy carrier$_{(f)}$ in fuel mix by building type$_{(b)}$ in climate zone$_{(z)}$* as the key parameters. The financial support policies do not affect the other parameters.

Parameter	**Policy**	**Likelihood** *(Very likely, Likely, Possible, Unlikely, Very unlikely)*	**Relative magnitude** *(Minor, Moderate, Major)*
Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$	Preferential loan	**Very likely** – Preferential loan policy likely to increase number of new buildings being renovated due to provided financial incentives. The conditions of the scheme are favourable enough to likely incentivise people to build houses who otherwise would not have done so. This judgment is based on data from a	**Moderate** – Preferential loan policy expected to have moderate impact as financial incentives not likely to spur major increase in number of buildings

		neighbouring country that implemented a similar scheme.	
	Tax rebate	**Very likely** - Tax rebate policy likely to increase number of new buildings being renovated due to provided financial incentives	**Moderate** – Tax rebate policy expected to have moderate impact as financial incentives not likely to spur major increase in number of buildings
Average annual specific energy use per m2 per building by type(b) in climate zone(z)	Preferential loan	**Very likely** - Preferential loan policy likely to decrease the average annual specific energy use as it has higher efficiency requirements than regulatory policies	**Moderate** - Preferential loan policy expected to have moderate impact as efficiency requirements are higher compared to the regulatory polices
	Tax rebate	**Very likely** – Tax rebate policy likely to decrease the average annual specific energy use as it has higher efficiency requirements than regulatory policies	**Moderate** – Tax rebate policy expected to have moderate impact as efficiency requirements are higher compared to the regulatory polices
Share of energy carrier(f) in fuel mix by type(b) in climate zone(z)	Preferential loan	**Likely** - Performance requirements of preferential loan policy likely lead to a change in the fuel mix	**Minor** - Preferential loan policy expected to have minor impact as share of energy carriers only might be affected marginally
	Tax rebate	**Likely** – Performance requirements of tax rebate policy likely lead to a change in the fuel mix	**Minor** – Tax rebate policy expected to have minor impact as share of energy carriers only might be affected marginally
Average floor area per building by building type(b) in climate zone(z)	Preferential loan	**Unlikely** - Performance requirements of preferential loan do not significantly affect *average floor area* of newly constructed buildings	[-]
	Tax rebate	**Unlikely** - Performance requirements of tax rebate do not significantly affect *average floor area* of newly constructed buildings	[-]
Energy carrier(f) emission factors	Preferential loan	**Unlikely** - Performance requirements of preferential loan do not significantly affect energy carrier emission factors	[-]
	Tax rebate	**Unlikely** - Performance requirements of tax rebate do not significantly affect energy carrier emission factors	[-]

8.3.4 Step 3: Identify the interaction between different policies (if relevant)

Where a package of several policies is being assessed, qualitatively assess overlapping and reinforcing effects between these different policies. A useful tool for this is a policy interaction matrix. An example of a policy interaction matrix is provided in Table 8.8, for users to adapt as needed.

Table 8.8: Example of policy interaction matrix

	Preferential loan for deep retrofit	**Preferential loan for construction of new building**	**Tax break for deep retrofit**
Preferential loan for deep retrofit	n/a		
Preferential loan for construction of new building	Independent	n/a	
Tax rebate for deep retrofit	Overlapping (major)	Independent	n/a

Users should qualitatively describe the interaction between different policies in the respective interaction category (*Independent*, *overlapping*, *reinforcing*, *overlapping and reinforcing*) as defined in Section 5.2.1 in Chapter 5. Where financial support policies overlap and/or reinforce each other, users should account for these effects in Step 4.

Box 8.10 provides an example of how to identify the interaction between different policies.

Box 8.10: Identifying interactions between different financial support policies

The experts in the Ministry of Building and Housing of Country A evaluate whether both newly introduced financial support policies (*preferential loan* and *tax rebate*) have overlapping and/or reinforcing effects. The qualitative analysis summarised in the table below reveals that the financial support policies overlap and reinforce each other. Thus, their combined impact may be greater or less than the sum of the individual impacts of implementing them separately. This overlapping and reinforcing effect should be considered when estimating each parameter value in Step 4.

	Preferential loan	**Tax rebate**
Preferential loan	n/a	
Tax rebate	**Overlapping and reinforcing (moderate)** The financial support schemes are overlapping and reinforcing. This implies that the policies have an overlapping component (i.e. combined impact is less than the sum of their individual impacts due complementary goals) but also a reinforcing component (i.e., combined impact is greater than the sum of their individual impacts of implementing them separately due to reinforcing dynamics).	n/a

8.3.5 Step 4. Estimate key parameters for financial support policies

The key estimation parameters that are affected by the financial support policies are *number of buildings (households)*, *average annual specific energy use* and *share of energy carrier in fuel mix.* For retrofitting, these two parameters are determined by the renovation rate (i.e., number of households) and the targeted efficiency level linked to the financial incentive. The renovation rate in turn depends on the attractiveness of the financial incentive and other behavioural factors. Financial support policies affect other parameters (i.e., *average floor area per building by building type* and *energy carrier emission factors*) to a lesser degree in most cases.

Where overlapping and/or reinforcing policies are identified in Step 3, these effects should be accounted for to avoid over or underestimating the parameter value. Where the policy does not affect either of the two estimation parameters, use baseline values estimated in Chapter 7.

Number of buildings by buildings type(b) in climate zone(z)

To estimate the *number of buildings by buildings type$_{(b)}$ in climate zone$_{(z)}$*, it is necessary to make informed assumptions on relevant aspects and drivers that determine the number of buildings being retrofitted (to a desired level) or newly constructed depending on the policy's focus. Table 8.9 provides an overview of aspects and drivers generally considered relevant when estimating the effect of financial support policies. However, these aspects and drivers vary in their level of importance in different countries. There may also be other aspects or drivers that are not listed. Therefore, users should always adapt Table 8.9 to their policy context and country. Box 8.11 shows how users can estimate the *number of buildings per type$_{(b)}$ in climate zone$_{(z)}$*.

Table 8.9: Overall aspects to consider when estimating the impact of financial support policies

Aspects and drivers	Description
Overall access to capital in country context	Assumption(s) on overall access to capital in respective country context for persons and/or entities eligible under the financial support policy. This aspect might include several components, such as: • Interest rates for public loans, private loans and equity • Overall conditions for loans (e.g., pay back periods) • Functioning and trust in financial system and institutions • Conditions around availability of foreign direct investments (FDI) • Rate of inflation All such factors determine the access to capital and thus whether and to what degree an introduced financial support policy spurs further investments in energy efficiency (i.e., by conducting retrofits or constructing energy-efficient new buildings) apart from baseline developments in the sector. **Example**: A country has a very low interest rate level and the preferential loan is only able to marginally improve the situation, leading to very limited diffusion.
Building supply market/ capacity considerations	Assumption(s) on ability of the building supply market to provide the services needed for the uptake of the retrofit of existing buildings and/or the construction of energy efficiency new buildings. **Example**: Only a limited number of contractors exist in the market, limiting the number of retrofits that can be carried out simultaneously, thus limiting the diffusion of the policy.
Trustworthiness and credibility of programme sponsor	Assumption(s) on how the targeted audience trusts the institution(s) or programme sponsor(s) implementing the financial support policy. **Example***:* The financial institution granting the preferential loans is very young and has not gained a solid reputation in the country. This reduces the trust in the institution, resulting in fewer people taking out a loan than was originally envisioned.

Skills and sophistication of programme sponsor	Assumption(s) on how well the programme sponsor is suited to successfully implement the financial support policy. **Example***:* Lengthy and complicated internal administrative procedures significantly slow down the speed with which grants or preferential loans are passed on to home owners. Delays of up to 3 years cause home owners to forego applying for the loan.
Dispersion of information on support scheme	Assumption(s) on how information about the financial support policy is dispersed to reach the targeted audience to inform potential beneficiaries of the existence of policy. **Example***:* Only a limited number of the potentially eligible households are aware of the existence of a preferential loan for retrofits.
Longevity of impacts	Assumption(s) on how lasting the effects of the financial support scheme will be. This might also link to the policy design. **Example**: A financial support scheme only receives public funding on an annual basis by the federal government, which critically hinders the uptake of a financial support policy due to concerns about the longevity of the scheme or limited financial resources to fully fund the activities.
Accessibility to programme	Assumption(s) on the ease of accessing the funding. For example, there may only be limited points of access to the financial support. **Example***:* Points of access exist only in certain urban regions. Many rural regions are excluded from the financial support policy.
Audit requirements	Assumption(s) on how the audit requirements defined in financial support policies affect their uptake.
Cultural/ behavioural response of home owners	Assumption(s) on how people react to price signals in the buildings sector. These include cultural and behavioural conditions around how willing home owners are to access financial support policies, but also aspects such as the share of the population renting vs. owning a home. **Example***:* In certain countries, home owners may react faster to financial support provided, as there is a cultural openness to using such financial support policies. In other countries, the share of renters may be very high, meaning that home owners are less likely to invest in deep retrofit, even though lucrative preferential loans exist.

Source: Adapted from Hayes et al., 2011

Box 8.11: Example of estimating the number of buildings per type$_{(b)}$ in climate zone$_{(z)}$

The analysis of regulatory policies in Section 8.2 revealed the following values for the number of buildings per type$_{(b)}$ in climate zone$_{(z)}$ for each year of the assessment period. Only the building type category A (single-family house) is listed because only single-family houses are eligible for support under the financial support policy.

Building type A in climate zone C: 190 new buildings in 2017 / 382 new buildings in 2018

Building type A in climate zone D: 441 new buildings in 2017 / 895 new buildings in 2018

As Country A has not implemented any financial support policies for energy-efficient new buildings before, the estimation on how the newly introduced policies affect the number of buildings cannot be based on ex-post monitored results of previously implemented policies, but instead is based on transparent analysis of all relevant aspects and drivers outlined in Table 8.9. Two experts with appropriate experience in the country’s buildings sector are consulted.

- **Overall access to capital in country context**: Overall, the access to capital in the country context is well-established with a network of local banks granting loans for housing construction. However, a share of more risk-averse local private banks is expected to be less willing to grant loans because of increased construction costs due to higher efficiency requirements similar to the previous financial conditions (i.e., interest rates and loan period). Nevertheless, a review of their current share in loans in house construction reveals that they only contribute marginally. Thus, the financial support policies are assumed to not be limited in their diffusion by current access to capital in the country context.
- **Market considerations**: Only a limited number of construction companies is currently prepared to construct energy-efficient new buildings with the efficiency requirements linked to the loan. Since companies will need time to build these capacities, the lack of knowledge will likely lead to a reduced uptake of the financial support policy in the first years, until the market conditions have adapted and more companies can fulfil such requirements.
- **Trustworthiness and credibility of programme sponsor**: The preferential loan policies are issued by a state-owned national bank. However, requests for preferential loans can be done via several selected local banks that fulfil certain requirements. In general, trustworthiness and credibility of both the state-owned national bank and the selected local banks is good and should not negatively affect the uptake of the financial support scheme. The tax rebates are directly granted in the annual tax return.
- **Skills and sophistication of programme sponsor**: Experience of the state-owned national bank and the local banks with granting preferential loans linked to energy efficiency improvements is rather limited, especially considering the required coordination between them and the need to also monitor the effective implementation of the energy efficiency requirements linked to the loan. Thus, certain coordination problems are expected in the first year after the policy has been introduced. No such problem is expected with the tax rebate, as the tax authorities have vast experience with granting tax rebates in diverse contexts.
- **Dispersion of information on support scheme**: Even though a public information campaign to inform eligible project developers about the available financing opportunity has been initiated, it is expected that this information might only reach about 70%-80% of eligible beneficiaries.
- **Longevity of impacts**: Funding for both financial support policies has been secured in the budget of the Ministry of Building and Housing for a period of five years until 2022. Thus, no impacts from a short and inadequate funding period are expected.
- **Points of access by customers to programme**: Due to the granting of preferential loans via local banks, points of access are available for basically all interested customers both in urban and rural areas. Tax rebates are directly granted by national tax authorities.
- **Audit requirements**: Audit requirements of financial support policies are not expected to have any impact on the uptake rate of policies.

Taking these assumptions on aspects and drivers into consideration, the two consulted experts estimate the impact of the financial support policies as follows below:

Building type A in climate zone C: increase by 3% to 6% over values estimated based on the regulatory scheme

Building type A in climate zone D: increase by 5% to 10% over values estimated based on the regulatory scheme

This results in the following number of buildings per type$_{(b)}$ in climate zone$_{(z)}$ for each year of the assessment period for single family houses.

2017:

Building type A in climate zone C: 196 to 201 new buildings

Building type A in climate zone D: 463 to 485 new buildings

2018:

Building type A in climate zone C: 393 to 405 new buildings

Building type A in climate zone D: 940 to 984 new buildings

Average annual specific energy use per m^2 by building type$_{(b)}$) in climate zone$_{(z)}$

Similar to the estimation of the *number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$* above, users should make informed assumptions on relevant aspects and drivers determining the number of buildings being retrofitted or newly constructed, depending on the policy's focus and the level of efficiency improvements achieved, to estimate the *average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$*.

Table 8.9 provides an overview of aspects and drivers generally considered relevant when estimating the effect of financial support policies. However, users should make additional informed assumptions on the actual level of energy efficiency improvements triggered by the financial support scheme as listed in Table 8.10 to estimate the average annual specific energy use for each year of the assessment period. Box 8.12 shows how users can estimate the *average annual specific energy use per m^2 by type$_{(b)}$ in climate zone$_{(z)}$.*

Table 8.10: Additional aspects to consider when estimating the average annual specific energy use per m^2 per building

Additional aspects and drivers	Description
Type and level of energy efficiency improvements	Assumption(s) on what type and level of energy efficiency improvements the financial support policy triggers. This is often directly linked to the policy. For example, a preferential loan might only be granted if the beneficiary also achieves a certain energy efficiency level. **Example**: A preferential loan scheme offers three options (e.g., with different interest rates and loan pack back durations) that are linked to the level of energy efficiency achieved with the retrofit. In this case, users need to focus on estimating the number of consumers that opt for each option.
Regional differences	Assumption(s) on whether regional differences result in different types of energy efficiency improvements.

	Example: In a region with few heating days and consequently low heating requirements, consumers might opt to only use preferential loans for some basic efficiency investments.

Box 8.12: Example: Estimating the average annual specific energy use per m^2 by type$_{(b)}$ in climate zone$_{(z)}$

The analysis of regulatory policies in Section 8.2 revealed the following values for the *average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$*. As explained above, this is mainly determined by the mandatory specifications of the building code and is uniform for each year of the assessment.

Building type A in climate zone C: 7,500 kWh/building

Building type A in climate zone D: 13,000 kWh/building

In addition to all assumptions made on aspects and drivers in Table 8.9, additional assumptions should be made on those aspects and drivers outlined in Table 8.10.

- **Type and level of energy efficiency improvements**: The conditions of both financial support policies are linked to two different levels of targeted energy efficiency, namely:
    - ***Lower level of efficiency***

      Building type A in climate zone C: 7,200 kWh/building

      Building type A in climate zone D: 12,500 kWh/building
    - ***Higher level of efficiency***

      Building type A in climate zone C: 7,000 kWh/building

      Building type A in climate zone D: 12,000 kWh/building
- **Regional differences**: Regional differences are expected to slightly affect the uptake of financial support policies. Experts expect to have 5-10% higher uptake in climate zone D as the potential for energy savings are higher in this region.

Due to the higher efficiency requirements linked to the financial support of the two respective policies, the *average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$* will change as follows below. Due to the level of uncertainty of how many eligible users will use each of the two financial support options, these are provided in ranges.

Building type A in climate zone C: 7,200 - 7,300 kWh/building

Building type A in climate zone D: 12,700 - 12,800 kWh/building

Share of energy carrier(f) in fuel mix by building type(b) in climate zone(z)

Similar to the estimation of the *number of buildings by building type$_{(b)}$ in climate zone$_{(z)}$* and *average annual specific energy use per m^2 by building type$_{(b)}$ in climate zone$_{(z)}$* above, users should make informed assumptions on relevant aspects and drivers determining the *share of each energy carrier$_{(f)}$* in the fuel mix by *building type$_{(b)}$* in *climate zone$_{(z)}$*.

It is important to note that for retrofitting of buildings, an increase in energy efficiency can also lead to a change in the fuel mix which should be reflected here (see also Chapter 6 on identification of impacts).

Table 8.11 provides an overview of the aspects that need to be considered when estimating the share of energy carriers in the fuel mix for each year of the assessment period. Box 8.13 shows how users can estimate the *share of energy carrier$_{(f)}$ in fuel mix by type$_{(b)}$ in climate zone$_{(z)}$*.

Table 8.11: Additional aspects to consider when estimating the share of energy carriers$_{(f)}$ in fuel mix

Additional aspects and drivers	Description
Requirements included in the policy regarding choice of fuels	Assumption(s) on the fuel mix that is required by the policy. Certain policies might require home owners to choose a certain fuel mix. **Example*:*** A policy might be linked to the implementation of biofuel technology or the use of highly energy-efficient heat pumps.
Effect of assumed energy efficiency improvements on fuel mix	Assumption(s) on whether and how energy efficiency improvements (depending on type and level of energy efficiency improvements identified in Table 8.10) determine fuel mix of buildings **Example*:*** A preferential loan scheme might trigger a deep retrofit level that allows a switch to a different fuel system. This is especially the case for very deep retrofits which often require only a small amount of heat that can be supplied by (geothermal) heat pumps.

Box 8.13: Example of estimating the share of energy carrier$_{(f)}$ in fuel mix by type$_{(b)}$ in climate zone$_{(z)}$

The analysis of regulatory policies in Step 4 in Section 8.2.4 revealed the following values for the *share of energy carrier$_{(f)}$* in fuel mix for building type A (i.e., single-family houses) in both climate zones for each year of the assessment.

2017 (after accounting only for regulatory policies)

Building type A in climate zone C:

- Natural gas: 9%
- Electricity: 91%

Building type A in climate zone D:

- Natural gas: 45%
- Electricity: 55%

2018 (after accounting only for regulatory policies)

Building type A in climate zone A:

- Natural gas: 8%
- Electricity: 92%

Building type A in climate zone B:

- Natural gas: 44%
- Electricity: 56%

In addition to all assumptions made on aspects and drivers in Table 8.9 and Table 8.10, additional assumptions should be made on those aspects and drivers outlined in Table 8.11.

- **Requirements included in the policy regarding choice of fuels**: Neither of the two financial support policies specify requirements on the choice of fuels
- **Effect of assumed energy efficiency improvements on fuel mix**: Generally, the higher level of requirements on efficiency specified in the financial support schemes further shift the share of energy carriers from natural gas toward electricity

Taking these assumptions on drivers and aspects into consideration, values for the *share of energy carrier*$_{(f)}$ *in fuel mix by building type*$_{(b)}$ *in climate zone*$_{(z)}$ for each year of the assessment change as follows after consultation with two experts:

2017 (after accounting for regulatory and financial support policies)

Building type A in climate zone C:

- Natural gas: 8%
- Electricity: 92%

Building type A in climate zone D:

- Natural gas: 43%
- Electricity: 57%

2018 (after accounting for regulatory *and* financial support policies)

Building type A in climate zone A:

- Natural gas: 7%
- Electricity: 93%

Building type A in climate zone B:

- Natural gas: 41%
- Electricity: 59%

8.3.6 Step 5: Estimate magnitude of other estimation parameters (if relevant)

Estimate the magnitude of the effect of the policy design characteristics on the other estimation parameters (i.e., those other than *number of buildings (households)*, *average annual specific energy use* and *share of energy carrier in fuel mix*).

Where overlapping and/or reinforcing policies are identified in Step 3, these effects should be accounted for to avoid over or underestimating the parameter value. Where the policy does not affect a given estimation parameter, use baseline values estimated in Chapter 7.

Table 8.12 describes how the other estimation parameters may be affected by financial support policies. Box 8.14 shows how users can estimate the other parameters, if relevant.

Table 8.12: Potential influence of financial support policies on other parameters

Parameter	Potential influence of financial support policies on other parameters
Average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$	In general, financial support policies do not impact *average floor area per building by building type$_{(b)}$ in climate zone$_{(z)}$*. However, it may be possible that generous financial support policies incentivise project developers to build more spacious buildings. Users should be aware of such potential effects and account for them where necessary.
Energy carrier$_{(f)}$ emission factors	In general, financial support policies do not impact energy carrier emission factors. However, users should account for any country-specific circumstances in which regulatory policies do so.

Box 8.14: Example of estimating other parameters

> As the analysis under Step 3 reveals, none of the other parameters is affected by the financial support policies, and thus no further estimation is required since the values estimated in Section 8.2 can be used.

8.4 Account for other barriers

There are several barriers that may attenuate the potential for energy savings under the policy being assessed. This step focuses on barriers not addressed by the policy directly. Information policies are considered in this step, since a lack of adequate information policies is considered to hinder the intended impact of regulatory policies and financial support policies.

It is *a key recommendation* to identify barriers not addressed by the policy and account for their effect on the relevant estimation parameters for each year of the assessment period. Users should follow the steps below to do this. The key estimation parameters affected by barriers are *number of buildings*, *average annual energy use per m^2* and *share of energy carrier in fuel mix.*

8.4.1 Step 1: Identify potential barriers

Identify and describe all potential barriers to the successful implementation of the policy. Table 8.13 lists the barrier categories, and provides a description of commonly encountered barriers and examples for each. Barriers should be identified and described for each relevant barrier category listed in the table, while also noting if no barriers are identified for a given barrier category. Users can add to this list any additional barriers they might identify through consulting relevant literature or national experts.

Box 8.15 provides an example of identifying and describing potential barriers.

Table 8.13: Barrier categories and example barriers

Barrier category	Commonly encountered barriers	Examples
Financial barriers	Absence of or lack of access to adequate funding opportunities and financing products	No financial instrument exists to incentivise households to renovate to higher standards, or no funding for new buildings to comply with a building code or high efficiency programme

	High ratio of investment cost to value of energy savings and inability to monetise the other benefits	Households or small and medium-sized enterprises are unwilling to invest in renovation work due to high upfront costs and long payback times for calculated energy savings
	Split incentives between landlords and tenants (only applies to rentals)	Landlords are unwilling to invest in energy efficiency measures as the benefits from lower energy bills do not accrue to them directly and they cannot raise the rent accordingly
	Risk-averse financiers	Lenders are unwilling to finance projects due to perceived or real risks associated with energy efficiency loans to households / SMEs (often due to a lack of information, uniformity and standards, for example in calculating energy savings)
	Small scale of residential energy efficiency projects	Banks are unwilling to finance residential energy efficiency measures due to high transaction costs associated with small and dispersed projects and developers
	Inability to securitise assets	Loans to residential energy efficiency projects may be associated with a lower proportion of securitised assets making them less attractive to financiers
Institutional and administrative barriers	Lack of strong / dedicated institutions to implement and enforce energy efficiency regulation	No government unit is clearly responsible for implementing energy efficiency policies or enforcement is insufficient
	Incoherent national and municipal energy regulations and standards	Cities and national government may have different energy efficiency requirements that are not compatible, thus reducing compliance
	Contradicting material or equipment standards (within a given jurisdiction)	Multiple building material standards are in competition with each other, have different requirements and have different means of compliance, which reduces uniformity and energy efficiency
	New buildings are not subject to building permitting processes	A large informal housing sector leading to buildings not going through normal building permitting process, which limits the means of building code enforcement
	Reluctance to enforce building code for building retrofits	Governments may be reluctant to enforce retrofitting obligations from existing building codes on private owners
	Corruption	High corruption levels can decrease compliance with standards
Market barriers	Inconsistent pricing structures (especially electricity subsidies) that disadvantage energy efficiency investments	Low electricity prices due to subsidies make energy efficiency measures less attractive for consumers
	High import duties on energy efficiency equipment or components	High import duties may exist on energy-efficient building components or appliances making them financially less attractive to purchase compared to inefficient products
Lack of trained and skilled personnel barriers	Lack of skills to deliver, maintain, and manage more energy-efficient buildings or building components	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards

	Lack of technical assistance or advice	Households or project promoters do not have access to advice on energy efficiency, making them less likely to initiate energy efficiency projects
	Lack of equipment testing or certification	Insufficient information is available for construction companies to choose equipment matching regulatory standards
Public acceptance barriers	Insufficient public acceptance of renovation works	Households not investing in renovation work due to the discomfort or inconvenience that renovations cause
	Insufficient acceptance of new, innovative technologies	Households unwilling to invest in a new building component or appliance they have not seen in operation under real-life conditions
Energy poverty and access barriers	Increased ability to afford comfort (the rebound effect)	Households increase heating/cooling energy consumption to achieve improved thermal comfort, due to lower energy bills after renovation work
Technology barriers	Lack of available energy efficiency equipment or components matching the regulatory standards or voluntary programme requirements	Pressure to support the local manufacturing base in middle income countries could lead to unavailability of equipment and building components matching standards
Lack of information policies	Lack of data, analysis or information to understand the benefits of energy efficiency	Increased energy efficiency is not specified in the policy or design because the methods to calculate the benefits of energy efficiency beyond energy and emissions savings are not readily available.
	Lack of information leads to uncertainty and risk	It is not clear to a homeowner whether installing a heat pump will save more energy than installing a boiler, due to lack of information
	Lack of awareness about standards	Building users, managers and construction companies are not adequately informed about regulatory standards
	Lack of awareness about the availability of financial instruments	Households or housing associations are not informed about the existence of policies to incentivise them to undertake renovation work

Source: Adapted from Schwarz, 2009; Sarkar and Singh, 2010; Hayes et al., 2011; Heiskanen, Matschoss and Kuusi, 2012 Lucon, Ürge-Vorsatz et al.; 2014.

Box 8.15: Example of identifying and describing all possible barriers

Based on the list of potential barriers in Table 8.13, the main barriers for the policy package of regulatory and financial support schemes are identified as follows:

- **Financial barriers**: Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements.
  - *→ Barrier not addressed for all buildings covered by the regulatory policy (i.e., mandatory building code) as financial support schemes (which provide financing by a public bank) only provided financial support for higher targeted level of energy efficiency*

- **Institutional and administrative barriers**: Informal housing sector not likely to comply with (or is not subject to) building permitting processes. Informal housing represents 10% of the sector.
- → *Barrier not addressed by regulatory or financial support policies*
- **Market barriers**: None
- **Lack of trained and skilled personnel barriers**: Insufficient number of trained architects and contractors to adequately implement the requirements of building codes and other standards
- → *Barrier not addressed by regulatory or financial support policies*
- **Public acceptance barriers**: None
- **Energy poverty and access barriers**: None
- **Technology barriers**: High local content requirements that reduce the supply of energy-efficient building components
- → *Barrier not addressed by regulatory or financial support policies*
- **Lack of information policies**: Lack of awareness about the availability of financial support policies by eligible single-house project developers
    - → *Barrier partially addressed, as specific information support policies have been implemented concurrently*

8.4.2 Step 2: Evaluate the likelihood and relative magnitude of barriers

Evaluate the likelihood and relative magnitude of each barrier to attenuate the potential energy savings achieved by the policy, using the scales in Table 8.14. Users should conduct this evaluation of likelihood and relative magnitude of barriers for all relevant estimation parameters. This is done for each year in the assessment period in order to account for a potential change of effect over time.

The evaluation of likelihood and magnitude may involve expert judgment, desk reviews and stakeholder consultations. Refer to the ICAT *Stakeholder Participation Guidance* (Chapter 8) for information on designing and conducting consultations, which can help with the identification and evaluation of barriers.

Box 8.16 provides an example of evaluating the likelihood and relative magnitude of barriers.

Box 8.16: Example of evaluating the likelihood and relative magnitude of barriers

Based on the selection of barriers in Step 1 in Section 8.4.1, analysis is done on the likelihood and relative magnitude of the respective barriers on each estimation parameter. This is done for each year in the assessment period in order to account for a potential change of effect over time. In the following example, the analysis is done for the parameter *number of buildings by building type$_{(b)}$* in climate zone$_{(z)}$ for each year of the assessment period (2017 and 2018).

2017:

Parameter	Barrier	Likelihood *(Very likely, Likely, Possible, Unlikely, Very unlikely)*	Relative magnitude *(Minor, Moderate, Major)*
Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$	**Financial barriers**		
	Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements	Very likely	Moderate
	Institutional and administrative barriers		
	Informal housing sector not likely to comply with (or is not subject to) building permitting processes. Informal housing represents 10% of the sector	Very likely	Moderate
	Lack of trained and skilled personnel barriers		
	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Very likely	Moderate
	Technology barriers		
	High local content requirements that reduce the supply of energy-efficient building components	Likely	Moderate
	Lack of information policies		
	Lack of awareness about the availability of financial support instruments by eligible single-house project developers	Likely	Minor

2018:

Only those barriers for which the likelihood and/or relative magnitude changed from the previous year are evaluated

Parameter	Barrier	Likelihood (Very likely, Likely, Possible, Unlikely, Very unlikely)	Relative magnitude (*Minor, Moderate, Major)*
Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$	**Lack of trained and skilled personnel barriers**		
	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	**Likely** – Change to *likely* from *very likely* in 2018 as market is expected to adapt relatively fast	**Minor** – Change to *minor* from *moderate* in 2018 as market is expected to adapt relatively fast

8.4.3 Step 3: Identify other policies that may help overcome identified barriers

For each barrier identified, identify other policies (that are not directly linked to the policy being assessed) that may help overcome the barrier. Estimate the potential for the policy to overcome the identified barriers, using a four-point scale (low, moderate, high, not applicable). Users should then adjust the barrier's relative magnitude, or note that the barrier is not relevant if other policies are deemed sufficient to overcome it.

Only the barriers which have not been overcome by other policies in the country will be further analysed in Step 4.

Box 8.17 provides an example of identifying and evaluating other policies in the country that may help overcome the identified barriers.

Box 8.17: Example of identifying and evaluating other policies that may help overcome identified barriers

For all barriers identified in the previous steps, other policies are evaluated to see whether they can help overcome the barriers. In Country A, two additional policies should be considered since they help to (partially) overcome the barriers. Whereas the barrier on high local content requirements is overcome by the policy intervention in the field, the barrier on share of new buildings that are not subject to building permitting processes is drastically reduced in effect by about 50%. Both have a high likelihood of helping to overcome the identified barriers.

Barrier	Policy 1: Change in administrative capacity to significantly lower share of informal housing sector	Policy 2: Change of legislation on local content requirements that allow prioritisation of particular objectives (such as environmental protection)
Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements	Not applicable	Not applicable

Informal housing sector not likely to comply with (or is not subject to) building permitting processes. Informal housing represents 10% of the sector	**High** – Policy aims to reduce newly constructed buildings in informal sector by 50% due to better administrative capacity and controls	Not applicable
Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Not applicable	Not applicable
High local content requirements that reduce the supply of energy-efficient building components	Not applicable	**High** – No restrictions on energy- efficient building components will exist from 2017 onwards
Lack of awareness about the availability of financial support instruments by eligible single-house project developers	Not applicable	Not applicable

8.4.4 Step 4: Determine how the identified barriers affect the estimation parameters

Determine how the identified barriers affect the estimation parameter values as follows:

1. **Determine the effect factor for each barrier on each relevant estimation parameter**: The effect factor reflects how much a certain barrier reduces the value of the respective parameter. For example, the outcome after accounting for barriers may indicate that an identified barrier reduces the number of retrofitted houses by 3% for each year of the assessment period.
2. **Determine overlaps between the barriers**: Identify whether and to what degree the effects of the barriers overlap, and account for this overlapping effect between barriers.
3. **Calculate the overall effect factors for all barriers, and add an uncertainty range if necessary**: Calculate the potential effect of all barriers while accounting for the potential overlap(s) between barriers. This outcome can be supported with an uncertainty range to account for uncertainty about the effect of one or multiple barriers.

Table 8.14 provides a set of examples to illustrate Step 4. Box 8.18 shows how users can determine how the barriers effect the parameters.

Table 8.14: Accounting for other barriers - Step 4

Parameter	Barrier	Effect factor analysis	Barrier overlap	Overall effect factor
Average annual specific energy use per m^2 per new building by type$_{(b)}$ in climate zone$_{(z)}$	**Economic and financial barriers**			
	High cost of some code-compliant air conditioners	+ 3-4%	Moderate overlap with high subsidies for electricity consumption	+ 2-3%
	Institutional and administrative barriers			
	High share of informal housing	+ 10-15%	No overlap with other barriers	+ 10-15%

	National code for new residential buildings has different requirements than several city-level codes	+ 4%	No overlap with other barriers	+ 4%
	Market barriers			
	High subsidies for electricity consumption	+ 5%	Minor overlap with high cost of energy-efficient air conditioners	+ 4.5%
	Lack of skilled personnel			
	No training programmes have been organised for building contractors	+ 5-7%	No overlap with other barriers	+ 5-7%

Box 8.18: Example: Determining how other barriers affect the parameters

Country A determines how the existing barriers affect the values of the different parameters as follows. This is done for each year of the assessment period in order to account for a potential change of effect over time. In the following example, the analysis is done for the number of buildings parameter for each year of the assessment period (2017 and 2018). To simplify this example, no further differentiation has been done between building type $_{(b)}$ in climate zone $_{(z)}$.

1. In the first step, the effect factor on the parameters for each barrier is determined. As this is the first ex-ante assessment in Country A, relatively large ranges are applied to account for the uncertainty with the overall effect of barriers to the different factors.
2. In the second step, the overlaps between the barriers are determined. All four remaining barriers are distinct in nature, without overlap between them.
3. As none of the barriers overlap, the barrier specific effect factors with the respective uncertainty ranges do not have to be further adapted. The aggregated effect of all existing barriers on the number of buildings per type $_{(b)}$ in climate zone $_{(z)}$ ranges 17.5% to 26% in 2017 and 11.5% to 20% in 2018.

2017

Parameter	Barrier list	Effect factor analysis	Barrier overlap	Overall effect factor
Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$	**Economic and financial barriers**			
	Risk-averse financiers (e.g., local private banks) may be unwilling to grant loans due to increased construction costs caused by mandatory efficiency requirements	Minus 5-7%	No overlap with other barriers	Minus 5-7%

	Institutional and administrative barriers			
	Informal housing sector not likely to comply with (or is not subject to) building permitting processes. Informal housing represents 10% of the sector.	Minus 2.5-5% (from originally 5-10% due to 50% reduction effect due to policy intervention identified under Step 3)	No overlap with other barriers	Minus 2.5-5%
	Lack of trained and skilled personnel barriers			
	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Minus 6-7%	No overlap with other barriers	Minus 6-7%
	Lack of information policies			
	Lack of awareness about the availability of financial support instruments by eligible single-house project developers	Minus 4-7%	No overlap with other barriers	Minus 4-7%
Aggregation of total effect of barriers on parameter				**Minus 17.5 - 26%**

2018

Only those barriers for which the effect factor changed from the previous year are listed in the following.

Parameter	Barrier list	Effect factor analysis	Barrier overlap	Overall effect factor
	Lack of trained and skilled personnel barriers			
Number of buildings per type$_{(b)}$ in climate zone$_{(z)}$	Insufficient number of trained architects, construction workers, etc. to adequately implement the requirements of building codes and other standards	Minus 0-1%	No overlap with other barriers	Minus 0-1%
Aggregation of total effect on barriers on parameter				**Minus 11.5 - 20%**

8.4.5 Step 5: Revise estimation parameter values

Based on the estimated overall effect factors for each barrier in Step 4, the final values for each estimation parameter are estimated. The parameter values estimated in Section 8.2 (for regulatory policies) or Section 8.3 (for financial support policies) are adapted using the overall effect factors of the existing barriers. Where barriers do not affect a parameter, simply use the previously estimated value.

The result is an estimate for the value of each parameter that accounts for all policy characteristics of the relevant policies and existing barriers. These values will be used in Section 8.5 to estimate the GHG emissions for each year of the assessment period.

The example for Approach 1 outlined in Box 8.19 shows how users can calculate parameter values after accounting for all relevant barriers.

Box 8.19: Example of calculating parameter values after accounting for all relevant barriers

In the following example, the barrier analysis is done for the number of buildings per type$_{(b)}$ in climate zone$_{(z)}$ parameter for each year of the assessment.

The estimated parameter values estimated in Sections 8.2 and 8.3 are as follows:

2017:

Building type A in climate zone C: 196 to 201 new buildings

Building type A in climate zone D: 463 to 485 new buildings

Building type B in climate zone C: 1176 new buildings

Building type B in climate zone D: 196 new buildings

2018:

Building type A in climate zone C: 393 to 405 new buildings

Building type A in climate zone D: 940 to 984 new buildings

Building type B in climate zone C: 2398 new buildings

Building type B in climate zone D: 396 new buildings

Each of these values has to be adjusted using the aggregated barrier effect factor for the respective parameter identified in Step 4 to calculate the parameter values after accounting for regulatory policies, financial support policies, and barriers.

2017 – Aggregated barrier effect factor of minus 17.5 - 26%

Building type A in climate zone C: 145 to 166 new buildings

Building type A in climate zone D: 343 to 400 new buildings

Building type B in climate zone C: 870 to 970 new buildings

Building type B in climate zone D: 145 to 162 new buildings

2018 – Aggregated barrier effect factor of minus 11.5 - 20%

Building type A in climate zone C: 314 to 358 new buildings

Building type A in climate zone D: 752 to 871 new buildings

Building type B in climate zone C: 1918 to 2122 new buildings

Building type B in climate zone D: 317 to 350 new buildings

8.5 Estimate ex-ante GHG emissions

It is a *key recommendation* to estimate the GHG emissions for each year of the assessment period using the ex-ante values for each estimation parameter. The values obtained in Section 8.4.5 for each parameter are used to estimate GHG emissions in the buildings sector using the formula introduced in Section 0.

Where users want to estimate the GHG emission reductions compared to a baseline, the baseline emissions for each year of the assessment period in Chapter 7 should be subtracted from the policy scenario GHG emissions accounting for all identified policies.

Box 8.20 shows how users can estimate the ex-ante GHG emissions using the estimated values for each estimation parameter. In addition, the calculations for both objectives of the assessment (i.e., estimation of GHG emission reductions due to implemented policies for new buildings between 2017 and 2020, and a comparison of the emission level to a sectoral target for buildings sector emissions in 2020) are shown.

Where the user's objective is to estimate the GHG emission reductions expected to be achieved by the policy, it is *a key recommendation* to estimate the GHG impacts of the policy by subtracting baseline emissions from policy scenario emissions.

Box 8.20: Example of estimating GHG emissions using estimated parameter values

Using the final values for each parameter after accounting for regulatory policies, financial support policies, and barriers, the policy scenario emissions can be estimated ex-ante for each year of the assessment.

* Note: The ex-ante GHG emissions estimates below are illustrative values only as not all parameter values have been estimated in the examples before in Box 8.19 for the barrier analysis. Refer to the example in Box 7.11 in Step 8 of Section 7.3.8 for the use of the estimation equation with actual parameter values.

The ex-ante assessment reveals the following estimated GHG emissions for both years of the assessment period.

2017:

Total ex-ante GHG emissions for all building types in all climate zones **=** 22,430 tCO_2e to 21,550 tCO_2e

2018:

Total ex-ante emissions for all building types in all climate zones = 44,920 tCO_2e to 43,650 tCO_2e

The ex-ante assessment of the buildings sector policy package had two separate objectives, which are discussed below.

Objective 1 - Estimation of emission reductions due to implemented policies for new buildings between 2017 and 2018

The first objective of the assessment has been to estimate the GHG emission reductions due to the implemented policy package for new buildings in 2017 and 2018. The estimated GHG baseline emissions in Section 0 have to be subtracted from the estimated policy scenario GHG emissions for each year of the assessment.

2017:

Emission reductions = 23,630 tCO_2e [estimated baseline emission for 2017] - 22,430 tCO_2e to 21,550 $ktCO_2e$ [estimated ex-ante policy scenario emissions] = 1,200 tCO_2e to 2,080 tCO_2e [estimated emissions reduction]

2018:

Emission reductions = 46,300 tCO_2 [estimated baseline emission] - 44,920 tCO_2e to 43,65 tCO_2e [estimated ex-ante policy scenario emissions] = 1,380 tCO_2e to 2,650 tCO_2e [estimated emissions reduction]

Objective 2 - Comparison of emission level to the sectoral target for buildings sector emissions in 2020

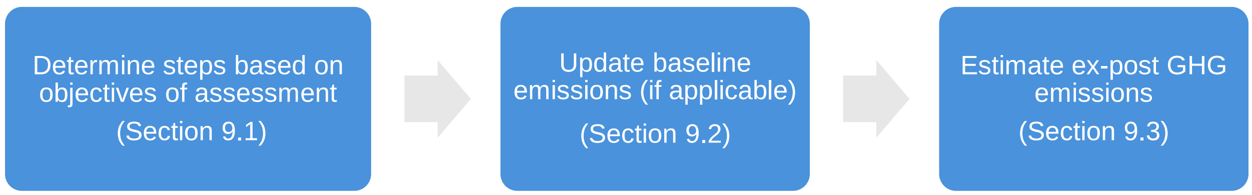
The second objective of the assessment is to compare the policy scenario emission level with the buildings sector emissions target for 2020, namely total emissions of 42,000 tCO_2e for new buildings in the residential sector. This target has been defined as part of the sectoral plan, and thus policymakers in Country A are interested in whether the introduced policy package of regulatory and financial support policies is sufficient to reach this sectoral target.

The comparison reveals that in the best-case scenario (lower-bound of the ex-ante estimation), sectoral emissions miss the target value of 42,000 tCO_2e by 1,650 tCO_2e. In the worst-case scenario (upper-bound of the ex-ante estimation), sectoral emissions miss the target value by 2,290 tCO_2e.

9. Estimating GHG Impacts Ex-Post

Ex-post impact assessment is a backward-looking assessment of the GHG impacts achieved by a policy to date. The GHG impacts can be assessed during the policy implementation period or in the years after implementation. In contrast to ex-ante estimates of GHG emissions, which are based on assumptions about future improvements in efficiency in the buildings sector, ex-post estimates are based on observed data collected during policy implementation period. Users that are estimating ex-ante GHG impacts only can skip this chapter.

Figure 9.1: Overview of steps in the chapter



Checklist of key recommendations

- Estimate the GHG impacts of the policy for each year of the assessment period

9.1 Introduction to estimating GHG impacts ex-post

Ex-post assessment can meet any of three main objectives, which are described below along with the sections of this chapter that are relevant to each.

Compare historical GHG emissions in the buildings sector to a sectoral target

Users may want to compare the policy scenario trajectory of buildings sector GHG emissions to a sectoral target. For example, a country's NDC or national climate policy plan might define a targeted GHG emission level for the buildings sector at a certain point in time (e.g., a stepwise emission reduction in the buildings sector from total emissions of 70 $MtCO_2e$ in 2005, to 60 $MtCO_2e$ in 2010 and to 50 $MtCO_2e$ in 2017). In such a case, the ex-post estimation of GHG emission levels in the buildings sector enables users to understand whether these emissions levels have been achieved with the implemented policies.

Users do not need to develop a baseline scenario to meet these objectives and follow just one step of the guidance below in Section 9.3.

Estimate achieved GHG emission reductions of implemented policies

Users may want to estimate the GHG emission reductions achieved by the implemented policies. In other words, users want to compare actual GHG emissions under the policy scenario with what would have happened in its absence under the baseline scenario. For example, users may be interested in the GHG emission reductions achieved in 2017 by a policy package introduced in 2010. This objective requires the determination of a baseline scenario to serve as the basis for calculating GHG emission reductions. The calculation requires the subtraction of baseline emissions from ex-post estimated policy scenario emissions.

To meet these objectives, users follow the steps in Sections 9.2 and 9.3.

Compare an ex-post assessment with an ex-ante assessment

Users might want to compare ex-ante estimates of GHG emission reductions with ex-post achieved GHG emission reductions to ascertain whether the performance of a buildings sector policy is in line with expectations. Such a comparison between ex-ante and ex-post assessments also provides an indication of the impact of policy design characteristics and other factors on the GHG emission reduction by policies (i.e., the factors and considerations set out in Chapter 8). For example, the ex-post assessment of a certain financial support policy reveals that GHG emission reductions achieved are 10% higher than estimated ex-ante. This may be due to the fact that some of the ex-ante assumptions on the main drivers have been too conservative. This comparison can help inform and enhance further ex-ante assessments.

To meet these objectives, users follow the steps in Sections 9.2 and 9.3.

9.2 Estimate or update baseline emissions

To estimate the GHG emission reductions achieved by the policy, baseline emissions need to be estimated. Baseline emissions should be recalculated each time an ex-post assessment is undertaken. Users that are not estimating emission reductions can skip this step.

The baseline scenario should include all other policies with a significant impact on emissions that were carried out both prior to the implementation of the policy, and after the implementation of the policy but prior to the ex-post assessment. The baseline scenario should also be recalculated, where necessary, to include updates to all non-policy drivers based on their observed values over the assessment period.

To update the baseline emissions, users should conduct all baseline estimation steps in Chapter 7 with updated values for each estimation parameter.

9.3 Estimate GHG impacts

It is a *key recommendation* to estimate the GHG impacts of the policy for each year of the assessment period. To estimate policy scenario GHG emissions ex-post, users should use monitored values for all estimation parameters for each year of the assessment period described in Equation 7.1 in Section 7.2 for each building stock type (existing buildings, retrofitted buildings, new buildings). Chapter 10 (monitoring performance over time) lists all the relevant indicators and parameters for which data should be gathered.

By following the monitoring plan described in that chapter, users should have the data they need to estimate ex-post GHG emissions. Where monitored values are not available for one or several of these parameters, users can follow the guidance set out in Chapter 8 to estimate values for each year of the assessment period.

Where the user's objective is to estimate total net change in GHG emissions resulting from the policy, subtract baseline emissions from policy scenario emissions