6 Identifying impacts: how renewable energy policies reduce GHG emissions

This chapter provides a method for identifying the most common GHG impacts of RE policies, and guidance for users to identify any additional impacts their policies may have. A subset of impacts that are considered significant is then taken from this list and included in the GHG assessment boundary. The chapter also provides a method for defining the assessment period. The steps in this chapter are closely interrelated. Users can carry out the steps in sequence or in parallel, and the process may be iterative.

Checklist of key recommendations

- Identify all potential GHG impacts of the policy and associated GHG source categories
- Develop a causal chain
- Include all significant GHG impacts in the GHG assessment boundary
- Define the assessment period

6.1 Identify GHG impacts

GHG impacts are the changes in GHG emissions that result from the policy. For most RE policies being assessed using this methodology, the sole relevant GHG impacts are likely to be reduced emissions from existing fossil fuel power plants and/or avoided emissions from new fossil fuel power plants that would have been built. For these policies, users may want to skip this section. For policies that may have other GHG impacts, such as emissions of methane (CH_4) and carbon dioxide (CO_2) from water reservoirs, users should follow the method in this section to ascertain the policy's GHG impacts.

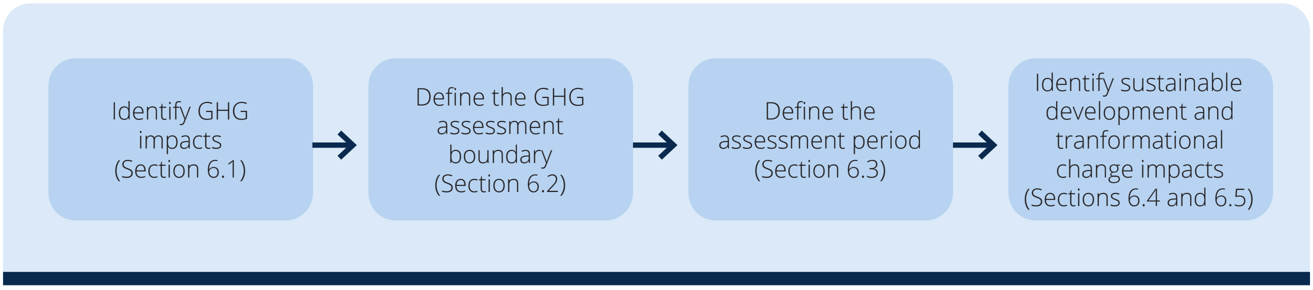
6.1.1 Identify intermediate effects

To identify the GHG impacts of a policy, it is useful to first consider how the policy is implemented by identifying the relevant inputs and activities associated with implementing the policy. Inputs are resources that go into implementing the policy, and activities are administrative activities involved in implementing the policy. These inputs and activities lead to intermediate effects, which are changes in behaviour, technology, processes or practices that result from the policy. These intermediate effects then lead to the policy's GHG impacts (the reduction in emissions).

Identification of intermediate effects enables a complete and accurate assessment, and is necessary to identify the potential GHG impacts of the policy and develop a causal chain. To identify the intermediate effects, users should identify the stakeholders, and the inputs and activities that are needed to implement the policy.

FIGURE **6.1**

Overview of steps in the chapter



6.1.2 Identify potential GHG impacts

It is a *key recommendation* to identify all potential GHG impacts of the policy and associated GHG source categories. A method for this is provided below, and further discussion on the process is available in the *Policy and Action Standard*. There are several types of GHG impacts to consider, such as those described in Table 6.1.

Users should consider impacts across the life cycle of electricity generation. For example, biomass and large hydro energy installations may cause indirect land-use change or material displacement impacts; if RE policies support such installations, these impacts need to be taken into consideration. CDM methodologies can help with the quantification of such impacts.[17] For example, CDM methodology *ACM0002: Grid-Connected Electricity Generation from Renewable Sources* includes a calculation method for quantifying CH_4 emissions from reservoirs.

By separately identifying and categorizing in-jurisdiction and out-of-jurisdiction impacts, users can more accurately link the GHG impacts to the relevant jurisdiction's inventory, targets and goals. This separate categorization also creates transparency around any potential double counting of out-of-jurisdiction impacts between jurisdictions. In some cases, a single impact may affect both in-jurisdiction and out-of-jurisdiction emissions, and separate tracking may not be feasible.

Stakeholder consultation can help to ensure the completeness of the list of GHG impacts. Refer to the ICAT *Stakeholder Participation Guide* (Chapter 8) for information on designing and conducting consultations. Relevant stakeholders may include

TABLE **6.1**

Types of GHG impacts

Type of GHG impact	Description	Example
Positive impact versus negative impact	Impacts that cause decrease or increase in GHG emissions	*Positive:* Reduced GHG emissions from existing and new fossil fuel power plants *Negative:* Increased emissions from manufacturing of RE-based systems/equipment
Intended impact versus unintended impact	Impacts that are both intentional and unintentional based on the original objectives of the policy	*Intended:* Reduced GHG emissions from fossil fuel power plants; reduced GHG emissions from national manufacturing of fossil fuel power plant equipment *Unintended:* Increased GHG emissions in other jurisdictions; increased GHG emissions from manufacturing of equipment for renewables
In-jurisdiction impact versus out-of-jurisdiction impact	In-jurisdiction impacts are those that occur inside the geographic area over which the implementing entity has authority, such as a city boundary or national boundary. Out-of-jurisdiction impacts occur outside the geopolitical boundary.	*In-jurisdiction:* Increased GHG emissions from manufacturing of equipment for renewables *In-jurisdiction:* Reduced GHG emissions from local manufacturing of equipment for fossil fuel power plants *Out-of-jurisdiction:* Increased GHG emissions in other jurisdictions (e.g. from electricity generation)
Short-term impact versus long-term impact	Impacts that are both nearer and more distant in time, based on the amount of time between implementation of the policy and the impact	*Short-term:* Reduced GHG emissions from operating fossil fuel power plants on the electricity grid *Long-term:* Reduced emissions from lower energy use due to increased cost of electricity

Source: Adapted from WRI (2014).

[17] Available at: https://cdm.unfccc.int/methodologies/index.html.

departments or ministries of energy, energy regulatory commissions, energy planning offices, power producers, investors, utilities, consumers and those affected at installation sites.

Users should identify all the GHG source categories associated with the GHG impacts of the policy. Example source categories are provided in Table 6.2. Source categories are the same for both RE projects and RE policies, so users with a project background should be familiar with all the main sources.

6.1.3 Develop a causal chain

It is a *key recommendation* to develop a causal chain. A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked and sequential stages of cause-and-effect relationships. A causal chain can help identify intermediate effects and GHG impacts not previously identified, and allows users to understand visually how policies lead to changes in emissions.

Figure 6.2 shows a high-level, illustrative example of a causal chain. Causal chains will vary from policy to policy, as will the strength of the links in the causal chain. Users should create their own causal chains, most likely with more (and different) detail from that shown in Figure 6.2.

Start by making a box for the policy, then add linkages from the policy to the identified intermediate effects and GHG impacts. The causal chain represents the flow of changes expected to occur as a result of the policy. Causal chains can also include inputs and activities. The *Policy and Action Standard* provides more information about developing causal chains.

Where users are also applying the ICAT *Sustainable Development Methodology*, the causal chain can be used as a starting point for a mapping exercise that includes sustainable development impacts as well as GHG impacts.

6.2 Define the GHG assessment boundary

The GHG assessment boundary defines the scope of the assessment in terms of the range of GHG impacts. It is a *key recommendation* to include all significant GHG impacts in the GHG assessment boundary. The identified GHG impacts and the associated GHG source categories should be

TABLE **6.2**

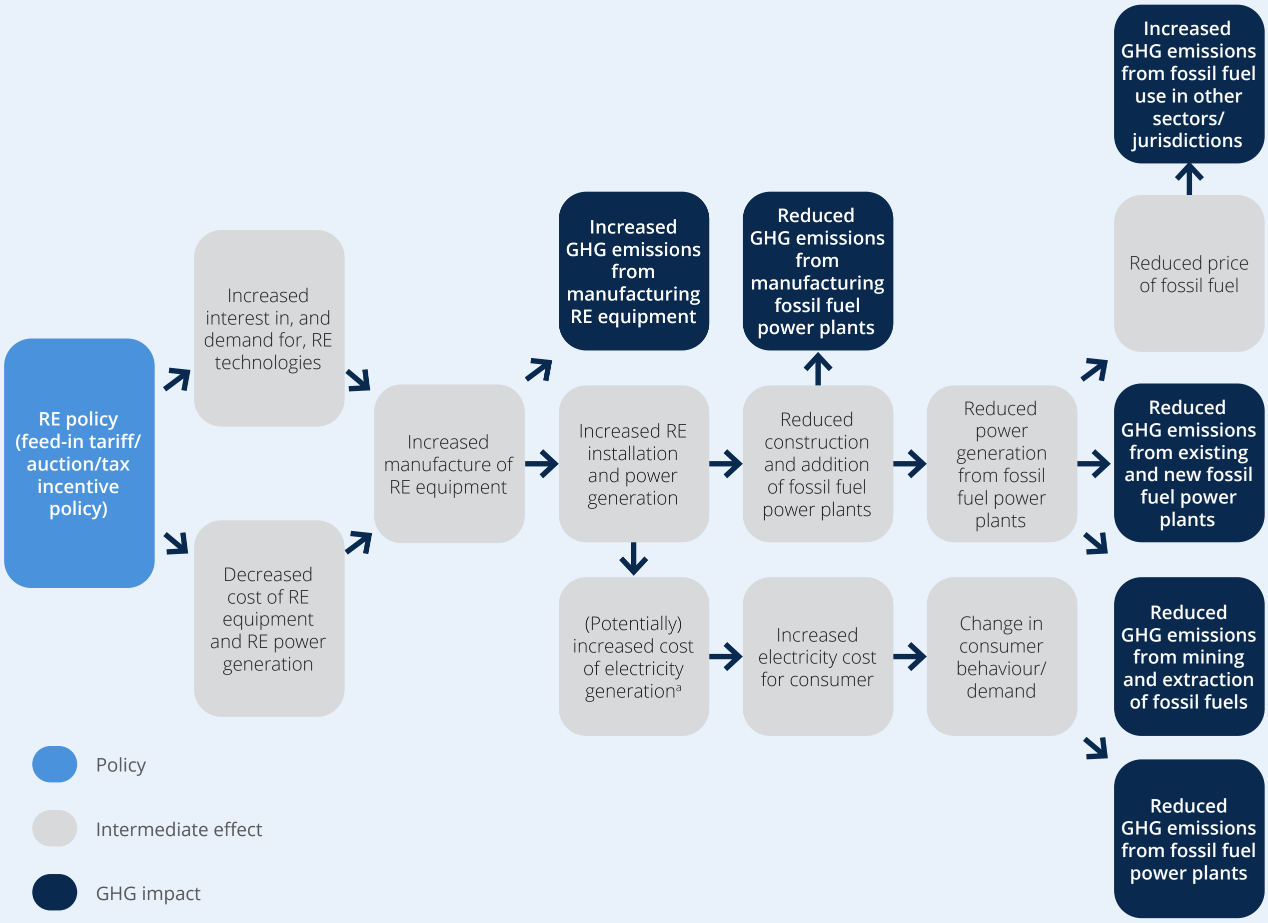
Examples of GHG sources for renewable energy policies

Source category	Description	Emitting entity or equipment	Relevant GHGs
Grid-connected electricity generation	CO_2 emissions from electricity generation in fossil fuel–fired power plants that are displaced due to the project activity	Grid-connected power plants	CO_2
Water reservoirs of hydropower plants	CH_4 and CO_2 emissions from reservoirs	Decaying organic matter in reservoirs	CH_4, CO_2
Fugitive emissions of geothermal power plants	Fugitive emissions of CH_4 and CO_2 from non-condensable gases contained in geothermal steam	Steam from power plant	CH_4, CO_2
Emissions from fossil fuel combustion in renewable energy plants	CO_2 emissions from combustion of fossil fuels for electricity generation in solar thermal power plants and geothermal power plants	Solar thermal and geothermal power plants	CO_2

Sources: WRI (2015); UNFCCC (2018a).

FIGURE **6.2**

Example causal chain for renewable energy policies



[a] Recent trends in renewable energy show that renewables are reaching grid parity in an increasing number of countries. Thus, the potential for this impact should be analysed carefully in each country-specific context.

categorized for magnitude and likelihood. They should be included in the GHG assessment boundary if they are categorized as moderate or major in magnitude, and very likely, likely or possible (i.e. deemed significant). The *Policy and Action Standard* provides further information about categorizing GHG impacts.

For most RE policies, only one GHG impact is likely to be significant – reduced GHG emissions from existing and new fossil fuel power plants. This is because, for most RE policies, this is the only GHG impact that is categorized as both very likely and of major magnitude.

Table 6.3 lists other GHG impacts and source categories. Users should check the list to ensure that each of the GHG impacts is categorized appropriately for the given policy, so that they can correctly identify impacts that need to be included in the GHG assessment boundary. Any GHG impacts that are categorized as moderate or major in magnitude, and very likely, likely or possible should be included in the GHG assessment boundary.

TABLE **6.3**

Example GHG impacts and source categories included/excluded in the GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included or excluded	Explanation
Reduced GHG emissions from existing and new fossil fuel power plants	CO_2	Very likely	Major	Included	The main GHG impact of RE policies
Reduced emissions from mining of fossil fuels	CH_4	Possible	Minor	Excluded	Considered insignificant for most RE policies, and is conservative to exclude
Increased emissions from manufacturing of RE equipment	CO_2, CH_4, N_2O	Possible	Minor	Excluded	Considered insignificant for most RE policies, and is offset by decreased emissions from construction of fossil fuel power plants
Reduced emissions from construction of fossil fuel power plants	CO_2, CH_4, N_2O	Possible	Minor	Excluded	Considered insignificant for most RE policies, and is offset by increased emissions from construction of RE power plants
Leakage emissions to other jurisdictions	CO_2, CH_4, N_2O	Possible	Minor	Excluded	Considered insignificant for most RE policies
Reduced emissions from lower energy use due to increased cost of electricity	CO_2, CH_4, N_2O	Possible	Minor	Excluded	Considered insignificant for most RE policies
For geothermal power plants, fugitive emissions of CH_4 and CO_2	CH_4, CO_2	Possible	Moderate	Policy dependent	Significant for RE policies involving geothermal power
For hydropower plants, emissions of CH_4 and CO_2 from water reservoirs	CH_4, CO_2	Possible	Moderate	Policy dependent	Significant for RE policies involving hydropower plants with reservoirs
For biomass power plants, emissions associated with agriculture and land-use change	CO_2, CH_4, N_2O	Very likely	Minor–major	Included	Significant for most biomass power plants

Source: Adapted from WRI (2015).
Abbreviation: N_2O, nitrous oxide.

6.3 Define the assessment period

The assessment period is the time period over which GHG impacts resulting from the policy are assessed. It is a *key recommendation* to define the assessment period.

For ex-ante assessments, the assessment period is usually determined by the longest-term impact included in the GHG assessment boundary. The assessment period can be longer than the policy implementation period, and should be as long as possible to capture the full range of significant impacts, based on when they are expected to occur.

For an ex-post assessment, the assessment period can be the period between the date the policy is implemented and the date of the assessment, or it can be a shorter period between these two dates. The assessment period for a combined ex-ante and ex-post assessment should consist of both an ex-ante assessment period and an ex-post assessment period.

Users should also consider the assessment objectives and stakeholders' needs when determining the assessment period. Where the objective is to understand the expected contribution of the policy towards achieving a country's NDC, it may be most appropriate to align the assessment period with the NDC implementation period (e.g. ending in 2030). To align with longer-term trends and planning, users should select an end date such as 2040 or 2050. In addition, users can separately estimate and report impacts over any other time periods that are relevant. For example, if the assessment period is 2020–2040, a user can separately estimate and report impacts over the periods 2020–2030, 2031–2040 and 2020–2040.

Where possible, users should align the assessment period with other assessments being conducted using ICAT methodologies. For example, where users are assessing the RE policy's sustainable development impacts using the ICAT *Sustainable Development Methodology* in addition to assessing GHG impacts, the assessment period should be the same for both the sustainable development and GHG impact assessments.

6.4 Identify sustainable development impacts (if relevant)

RE policies generate multiple sustainable development impacts in addition to their GHG impacts. Sustainable development impacts are changes in environmental, social or economic conditions that result from a policy or action – for example, changes in economic activity, employment, public health, air quality and energy security.

Refer to the ICAT *Sustainable Development Methodology* for the method for conducting an assessment of sustainable development impacts. Table 6.4 lists examples of sustainable development impacts and indicators that may be associated with RE policies, categorized according to the ICAT *Sustainable Development Methodology*. The SDGs most directly relevant to each impact category are indicated in parentheses.

6.5 Identify transformational change impacts (if relevant)

RE policies may lead to significant penetration of RE technologies, mobilize private sector investment in RE deployment and result in significant shares of RE in the energy mix of a country. A high share of renewable electricity fundamentally changes a country's electricity system and can provide a basis for further deployment of RE across the energy sector as a whole. In this way, RE policies may deliver transformational change impacts in addition to achieving GHG emissions reductions. In the context of GHG mitigation, transformational change can be understood as a fundamental, sustained systemic change that disrupts established high-GHG emissions development pathways and contributes to zero-carbon development, in line with the goals of the Paris Agreement and the SDGs. The ICAT *Transformational Change Methodology* provides guidance on assessing the transformational impacts of policies and their ability to influence the processes of change towards low-GHG emissions development, overcome barriers to systemic change, ensure a zero-carbon development and contribute to transformational outcomes.

Refer to the ICAT *Transformational Change Methodology* for more information on assessing transformational impacts of policies through an analysis of process and outcome characteristics.

TABLE 6.4

Examples of sustainable development impacts and indicators relevant to renewable energy policies

Impact categories	Indicators
Environmental impacts	
Air quality and health impacts of air pollution (SDGs 3, 11, 12)	• Emissions of air pollutants such as particulate matter ($PM_{2.5}$, PM_{10}), ammonia, ground-level ozone (resulting from volatile organic compounds – VOCs, and nitrogen oxides – NO_x), carbon monoxide, sulfur dioxide, nitrogen dioxide, fly ash, dust, lead, mercury and other toxic pollutants (tonnes/year) • Air pollutants concentration (mg/m^3) • Aerosol particles concentration (mg/m^3) • Indoor and outdoor air quality • Morbidity (disability-adjusted life years – DALYs, quality-adjusted life years – QALYs, and averted disability-adjusted life years – ADALYs) • Mortality (avoided premature deaths per year)
Energy (SDG 7)	• Energy consumption • Energy efficiency • Energy generated by source • RE generation • RE share of total final energy consumption • Primary energy intensity of the economy (e.g. tonnes of oil equivalent/gross domestic product)
Depletion of non-renewable resources	• Consumption of mineral resources • Consumption of fossil fuels • Scarcity of resources
Social impacts	
Access to clean, reliable and affordable energy (SDG 7)	• Percentage of population with access to clean, reliable and affordable energy • Price of energy • Emissions per unit of energy • Number and length of service interruptions
Economic impacts	
Jobs (SDG 8)	• Number of people employed • Number of people unemployed • Employment rate • Unemployment rate • Number of jobs, including short-term jobs and long-term jobs in different sectors • Number of new jobs created in different sectors
New business opportunities (SDG 8)	• Number of new companies • Revenue and profit • Amount of new investment • Number of active long-term partnerships
Growth of new sustainable industries (SDGs 7, 17)	• Amount of investment in clean technology sector • Revenue and profit from clean technology sector • Number of projects

TABLE **6.4,** continued

Examples of sustainable development impacts and indicators relevant to renewable energy policies

Impact categories	Indicators
Prices of goods and services	• Energy prices
Costs and cost savings	• Fuel costs or cost savings • Health-care costs or cost savings • Economic costs of human health losses from air pollution based on social welfare indicator (ADALYs monetized in terms of social welfare valuation, based on willingness to pay – value of a statistical life estimates) or national accounts indicator (ADALYs monetized based on foregone output estimates, based on productivity/wage approaches)
Government budget surplus/deficit	• Annual revenue • Annual expenditures • Annual surplus or deficit
Energy independence	• Net imports of fossil fuels (coal, oil, natural gas)

Source: Adapted from ICAT *Sustainable Development Methodology*.

Examples of indicators for transformational impacts of RE policies are:[18]

- annual investments in RE technologies as a percentage of total investment in all energy sources
- percentage of total energy sector employees working in the RE sector
- number of new local enterprises providing RE services established
- value of RE-related procurement orders placed within the national supply chain.

[18] Singh and Vieweg (2015).