UNITED NATIONS DEVELOPMENT PROGRAMME

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GUIDEBOOK

on the methodology for financial assessments to address climate change

CHAPTER III: ENERGY SECTOR

(mitigation of climate change)

2026

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About this publication

This methodology is an update to the first financial assessment methodology, which was released in 2009. The objective of this methodology is to support countries to implement their climate targets and to identify, reallocate, mobilize and manage the required financial resources and to create a fiscal framework conducive for climate action.

The update to this methodology was developed under UNDP's Climate Promise by the *Pledge to Impact* Programme. Delivered in collaboration with a wide variety of partners, the initiative has supported over 120 countries to enhance and implement Nationally Determined Contributions (NDCs) under the Paris Agreement. From Pledge to Impact is generously supported by the governments of Germany, Japan, United Kingdom, Sweden, Belgium, Spain, Iceland, the Netherlands, Portugal and other UNDP core contributors. This programme underpins UNDP's contribution to the NDC Partnership.

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About this Guidebook

As countries identify their national climate change targets—notably through Nationally Determined Contributions (NDCs) under the Paris Agreement—the need exists to break down targets into concrete steps of action, determine a financial framework to implement actions and achieve targets, and identify policy measures to facilitate the necessary changes that support low-emission development and a low-carbon future.

A key component to support this transformation is through assessing national investment flows and financial flows to address climate change. Many countries have used this method to articulate an effective and appropriate national response to climate change.

This Guidebook responds to the needs of countries to have a clear approach to support the implementation of national climate targets in the context of sustainable development that duly accounts for their national circumstances, capacities and resources.

Between 2008 and 2024, 60 investment flow and financial flow assessments were conducted worldwide, with more than 1,000 national stakeholders engaged in the technical and political aspects of the assessments. Since the adoption of the Paris Agreement and the development of NDCs, the methodology has helped countries utilize financial assessments to develop a pathway to NDC implementation.

While this methodology was first developed in 2008, an update has taken place in 2025. This Guidebook is a living document, which will continue to be improved based upon the experiences of those using it. Over the years, the methodology to carry out financial assessments to address climate change has been continually reviewed and updated regarding its user friendliness, feasibility of implementation and sectoral scope. Comments are invited. Please send feedback to Susanne Olbrisch (susanne.olbrisch@undp.org).

For more information, visit https://climatepromise.undp.org/tags/investment-and-financial-flows-assessments.

Contents

List of acronyms and abbreviations

BAU	Business-as-usual
BS	Baseline scenario
CDM	Clean Development Mechanism
CH_4	Methane
CHP	Combined heat and power
CO_2	Carbon dioxide
FDI	Foreign direct investment
FF	Financial Flow
GCF	Green Climate Fund
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
IEA	International Energy Agency
IF	Investment Flow
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
LPG	Liquid petroleum gas
LT-LEDS	Long-term Low-Emission Development Strategy
N_2O	Nitrous oxide
NDC	Nationally Determined Contribution
NGO	Non-governmental organization
O&M	Operation and maintenance
PV	Photo-voltaic
SO_2	Sulphur dioxide
UN FAO	United Nations Food and Agriculture Organization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Chapters I and II of this guide provide the methodology on how to carry out a financial assessment. This chapter provides additional information needed to carry out a financial assessment in the **energy sector**. To avoid repetition, some of the information provided in Chapter II that is relevant to all sectors is not included in this chapter. Careful reading of Chapter II before this chapter is highly recommended.

3.1 Introduction

The energy sector is the largest source of CO_2 emissions. Reducing energy sector emissions is therefore essential to limit global warming.[1] Between 2015 and 2019, coal was the single largest contributor to energy sector CO_2 emissions, accounting for about 44 percent of emissions in 2019. Oil accounted for about 34 percent and natural gas accounted for about 22 percent of energy sector CO_2 emissions between 2015 and 2019. Coal, oil and natural gas CO_2 emissions grew by 1.2 percent, 2 percent and 12.7 percent, respectively (annual rates of 0.31 percent, 0.5 percent and 3 percent, respectively).[2] Moreover, energy sector emissions are growing faster than those of other sectors in rapidly industrializing countries.

Energy sector mitigation options can reduce GHG emissions while at the same time contributing to sustainable development and improving living standards through potential co-benefits. Co-benefits of mitigation measures may be reflected in social, environmental and economic indicators, as described in the below examples.

- Abating local air pollution, for example through incorporating cleaner energy sources and technologies, can reduce damage to humans and ecological systems.
- Decreasing dependency on energy imports by using locally available and/or cheaper energy sources and more efficient energy generation or end-use technologies can improve energy security.
- Facilitating access to modern energy services, such as replacing biomass burning for cooking, lighting and heating with electricity, can reduce negative health impacts from biomass burning.
- Reducing the cost of energy can widen access to affordable energy.
- Adopting new production capacities and service subsectors, for example renewable energy power facilities, electricity distribution services and associated construction and maintenance, can create employment opportunities and boost green jobs.

Some mitigation measures may result in net savings due to reductions in fuel requirements. That would be the case, for example, if fuel savings derived from a mitigation option (e.g., an energy efficiency improvement programme) over a certain period overcompensated the associated investment (e.g., in more efficient electric equipment), as well as operation and maintenance costs. In addition, mitigation measures that involve infrastructure investments will have long-term GHG and non-GHG benefits due to the long lifetimes of infrastructure capital stock. Such investments include investments in energy supply infrastructure (e.g., new power plants), and energy end-use infrastructure (e.g., energy-intensive industrial production facilities, buildings and transportation infrastructure).

1 IPCC (2023). Sixth Assessment Report, Working Group III: Mitigation of Climate Change, Chapter 6: Energy Systems.
2 Ibid.

Depending on the activities or measures identified in the national target that is being assessed (Nationally Determined Contributions (NDCs), report on Long-term Low-Emission Development Strategies (LT-LEDS)), the finance assessment may only focus on a limited number of key mitigation options applicable in priority energy subsectors rather than aiming at estimating the full cost of implementing all possible mitigation options. This implies (as reflected in the step-by-step description below) that the assessment team will have to scope and screen mitigation options to be included in the assessment exercise according to the country's development needs and strategies as well as other relevant criteria from the country's standpoint (e.g., cost effectiveness, GHG mitigation potential, etc.). Before approaching this scoping and screening step it is important to keep in mind the wide variety of mitigation options available in the energy sector. These options may encompass measures to be implemented at different energy supply and demand-side subsectors. An illustrative list of energy sources and carriers, conversion and end-use technologies and possible end-use subsectors may be useful to help define relevant subsectors (Figure 3.1).

Figure 3.1: Scope of the energy sector, potential elements to consider

Energy sources	Conversion and process technologies	Energy carriers	End-use technologies	End-use subsectors
Coal	Combustion/ Combined heat and power (CHP)	Coal	Industrial processes	**Industrial** • Production • Space heating • Lighting
Oil	Liquefaction	Refined liquids	Industrial heat	
Natural gas	Coal wash and coke	Natural gas and CBM	Industrial electricity	**Commercial** • Space heating • Air conditioning • Lighting
Coal bed methane	Heat plants	Synthesis gas	Commercial space heating	
Uranium	Oil refining	Electricity	Commercial air conditioning	**Residential (urban & rural)** • Lighting • Cooking • Water & space heating
Biomass	Fuel cell power/ Combined heat and power (CHP)	Heat	Urban cooking and water heating	
Geothermal	Hydrogen production	Biogas	Urban space heating	**Agricultural** • Electric motors • Processing • Irrigation • Farming Machines
Hydro	Ethanol production	Hydrogen	Urban air conditioning	
Solar	Gasifier/digester		Lighting and appliances	**Transport** • Air • Ship • Road • Rail • Pipeline
Wind	Hydro power		Rural cooking and water heating	
	Solar power			
	Wind power		Agricultural processes	

Source: E.D. Larson, P. DeLaquil, Z. Wu, W. Chen and P. Gao (2002). "Exploring implications to 2050 of energy technology options for China." Prepared for the Sixth Greenhouse Gas Control Technologies Conference, Kyoto, Japan, 30 September-4 October 2002.

Note: The table above is presented for illustration purposes only. Not all the items listed are always present in different countries; for the purpose of the finance assessment only some of them (or even other subsectors defined at different levels of aggregation) might be selected.

Mitigation options will typically involve switching from technologies or energy carriers with high GHG emissions to cleaner alternatives, measures to improve end-user energy efficiency or reducing fugitive emissions from energy distribution or transportation services.

Note that some energy-related mitigation options will overlap with other sectors, such as mitigation options associated with the production of wood and agricultural biomass for biofuel production (e.g., to reduce N_2O emissions from fertilizer use). Since these can be seen as forestry and agriculture mitigation options they are explained in the chapters on forestry and on agriculture to avoid double counting.

The parts of Figure 3.1 that are relevant to a finance assessment in a particular country is entirely country-specific, as discussed below in section 3.2. Each country starting a finance assessment will have to choose from a large number of mitigation options that may be implemented in the energy supply side (or a specific supply subsector, such as the extraction of primary fuels, processing and transformation to secondary and tertiary forms of energy, etc.) as well as in various end-use sectors. End users include those that utilize (or "demand") energy, such as industrial production and residential energy use.

The finance assessment is a means to support countries to implement their national climate targets, and almost all countries have identified the energy sector as part of their NDC and LT-LEDS. The level to which specific measures or subsectors of action have been identified differ however, and typically a country must break down the energy target into more concrete measures and actions for the finance assessment. This step is not only a technical step, but it also requires input, ownership and oversight by policymakers to ensure the measures considered in the finance assessment are realistic and are endorsed by decisionmakers.

Just to provide a few examples, the energy supply side subsectors may adopt mitigation measures that reduce either:

1. combustion emissions from energy producing and fuel extraction and conversion industries (e.g., by substituting fuels with high GHG emissions for cleaner options in power plants, adopting cleaner technologies as when investing in combined heat and power facilities, etc.); or

2. fugitive emissions, for example from the extraction, processing, storage and transport of fuels.

Mitigation measures on the energy demand-side (end-use) subsectors reduce either:

1. energy demand via higher efficiency in end-use technologies for primary, industrial or service sectors (transportation, energy, building, etc.), production (e.g., higher efficiency boilers and appliances); or

2. the use of fossil fuels through substitution measures (e.g., gas or electric domestic and industrial water heating converted to solar water heating).

More generally, reductions in energy-related GHG emissions can be achieved through either improved efficiency in energy use or production or reducing emissions per unit of energy production through technological or energy source changes. Table 3-1 lists mitigation measures for each of these categories of measures. More specific mitigation measures are discussed below in section 3.2.

3.2 Application of the financial assessment methodology to mitigation in the energy sector

This section describes how the methodology described in Chapter II can be applied to identify shifts and increases in investment and financial flows to implement key mitigation options in the energy sector.

As described in Chapter II, the financial assessment involves a series of steps, which are:

Step 1. Establish key parameters of the assessment.

Step 2. Compile historical IF, FF and O&M cost data (and subsidy cost data if included explicitly) and other input data for scenarios.

Step 3. Define baseline scenario.

Step 4. Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the baseline scenario.

Step 5. Define target scenario.

Step 6. Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly). for the target scenario

Step 7. Calculate the changes in IF, FF and O&M costs (and in subsidy costs if included explicitly) needed to implement target scenario.

Step 8. Identify policy implications.

Step 1.

Establish key parameters of the assessment.

Define detailed scope of the sector.

In this step, the assessment team will define the precise subsectors that are to be included in the financial assessment. This involves selecting the specific processes, activities, entities and subnational areas or regions to be included in the energy sector for the purpose of the financial assessment. It is recommended to include the most important subsectors of the energy supply subsector (such as coal or wind), as well as the most important end-use subsectors (such as residential and transport). The selection of the subsectors, and exactly how broadly or narrowly they are defined, should depend on the national target being assessed (NDC, LT-LEDS or other).

National circumstances will play a role in the scoping, depending on the structure of each subsector and its relative importance in terms of GHG emissions, opportunities for effective mitigation, contribution to the national economy and potential for economic growth, and their relationship to national and sectoral development plans. This choice should also depend on data availability, cost effectiveness (e.g. US dollars per tonne of GHG reduced and absolute costs), and consider the scope of (and subsectors included in) mitigation assessments previously completed, such as the analysis of mitigation options in the context of the National Communications. The reasons for the selected scope should be explained in the introduction and conclusion of the finance assessment report.

Energy supply subsectors may be defined in terms of a specific production process or energy carrier (for instance, electricity generation, coal production) or alternatively by defining a whole production chain linking a specific energy carrier and the related energy source (such as coal based-electricity).

Similarly, there are numerous ways to define energy end-use subsectors. The simplest definition, which is often applied, identifies just three subsectors: industry, residential and transport (see, for example, the Fourth Assessment Report of IPCC). However, end-use subsectors could be broken down further, for example to five end-use subsectors: industrial, commercial, residential (urban and rural), agricultural and transport (as is done in Figure 3.1). How countries choose to define their end-use subsectors should depend on national circumstances, including the scope of energy supply subsectors, energy supply and demand technologies and the relative economic importance of different sectors, etc., and priorities, as well as on data availability and compatibility with other sources of data, such as National Communications and sectoral studies.

It should be kept in mind that the aggregation level should be compatible with usual practices of sectoral analysis in the country. For example, if it is customary to conduct sectoral analysis using a specific analytical model (e.g., to make projections, estimates and calculate investment and operating cost needs) the level of aggregation adopted for the financial assessment should be compatible with that model and data. In any case, data collection, processing and storage should build on existing structures and practices rather than establishing parallel systems.

Important direct linkages between the energy sector, as defined for the financial assessment, and other sectors should be noted. For example, the energy sector receives important inputs from the agriculture and forestry, waste management and water management sectors. The agriculture and forestry sectors are key raw material suppliers for biofuel production. The waste management sector is a source of energy through waste incineration and the collection and use of landfill methane. The water management sector provides inputs for hydropower generation and for cooling in electricity and heat production. Care should be taken to avoid double-counting of investment and financial flows due to sectoral overlaps (e.g., substitution of energy intensive materials with woody biomass could be included in energy mitigation or forestry mitigation), and inconsistent results (e.g., if hydropower development is a mitigation option for the energy sector, adaptation measures in the water sector should not assume pre-hydropower development conditions). Whenever such overlaps arise due to the chosen sectors included in a country's financial assessment, a specific subsection should indicate how double counting will be avoided (e.g., by stating the processes and/or options to be included in each sector).

Specify base year and assessment period.

The base year will be the most recent year for which historical data is available. The assessment period should match the timeframe of the target document that is being assessed in the financial assessment, e.g. many NDCs use a time frame until 2030 and many LT-LEDS use a timeframe until 2050. Care should be taken that the assessment period is not too short, as many investments in the energy sector have a particularly long lifetime, so options can only be properly assessed over a longer period. In any case, the reasons for selecting a given base year and time horizon as well as the hypotheses underlying the investment and financial flows estimates need to be documented in the finance assessment report. This will be key to understand the results of the assessment.

Identify the target to be assessed and mitigation measures.

The selected target (i.e., NDC, LT-LEDS, national climate change strategy) usually contains multiple goals. The target may be overarching and visionary in nature and may need to be broken down into concrete measures that can be costed and assessed. This is not only a technical exercise and should be done in consultation with policymakers to ensure the measures identified are realistic and have the buy-in of decisionmakers. A preliminary set of mitigation options must be identified for each relevant energy supply and each energy end-use subsector selected for the assessment (refer to Table 3.1 for a list of general mitigation options by subsector). The IPCC Working Group III Report of the Fourth Assessment Report[3] provides more detailed descriptions of mitigation measures for the energy supply and energy end-use subsectors.

The selection of options should be based on the sectoral scope, the country priorities for the sector, previous results from analyses of mitigation priorities (e.g., from National Communications), consistency with national and sectoral development plans and goals and current and expected future energy supply and demand characteristics.

Other criteria that a country may consider for prioritizing mitigation options include:

- capital and operation costs;
- cost effectiveness (cost per tonne of GHG abated);
- GHG mitigation potential;
- environmental and social co-benefits; and
- economic co-benefits at the macro and micro levels (balance of payment and growth impacts, development impacts, job creation, etc.).

The result of this identification and prioritization exercise would be a short list of mitigation options.

[3] IPCC (2007). "Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," B. Metz, O.R. Davidson, P.R. Bosch, L.A. Meyer (eds.), Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 851 pp.

Table 3.1: Energy sector mitigation measures

Primary subsector	Secondary subsector	Mitigation measures: Improve efficiency of energy use	Mitigation measures: Reduce emissions per unit of energy
Energy supply	**Electricity and heat generation** (power plants, combined heat and power (CHP) plants, heat plants)	Make plant efficiency improvements (upgrade existing plants, build new higher efficiency plants).	Switch to lower carbon fossil fuels (e.g., coal to gas). Switch to renewable sources (solar, wind, tidal, hydro).
	Electricity transmission and distribution and heat distribution		Reduce transmission and distribution losses of electricity. Reduce distribution losses of steam. Reduce sulfur hexafluoride (SF_6) and perfluorinated hydrocarbon (PFC) leakage from electrical transmission and distribution equipment.
	Oil and natural gas industry	Make efficiency improvements at oil refineries and natural gas processing facilities.	Reduce fugitive emissions from oil and gas production by flaring CH_4 rather than venting, and/or collection and utilization rather than venting and flaring. Reduce fugitive emissions of CH_4 from natural gas transportation and distribution systems.
	Coal industry	Make efficiency improvements at coal processing facilities.	Reduce fugitive emissions from coal mining by CH_4 collection and utilization.
	Biofuels (e.g., production of charcoal, ethanol, biodiesel and peat; anaerobic digestion of organic wastes)	Make efficiency improvements in charcoal manufacture and ethanol production.	Reduce CH_4 leakage from anaerobic digesters.

Table 3.1: Energy sector mitigation measures *(continued)*

Primary subsector	Secondary subsector	Mitigation measures: Improve efficiency of energy use	Mitigation measures: Reduce emissions per unit of energy
Energy demand	**Industrial production**	Use efficient end-use electrical equipment. Recover heat and power.	
	Transport: Road traffic	Use higher efficiency vehicles, including hybrids, cleaner diesel vehicles and improved structural design vehicles. Improve maintenance of vehicles. Make modal shifts from road to rail and public transport systems and to non-motorized transport (cycling and walking). Improve land-use and transport planning.	Utilize biofuels.
	Agriculture	Adopt higher efficiency motors and vehicles.	Use renewable energy for pumping water/irrigation.
	Buildings (commercial, institutional and residential)	Make lighting and daylighting* more efficient. Make electrical and gas appliances and heating and cooling devices more efficient. Improve cookstoves. Improve insulation and air sealing. Improve building design and siting.	Switch to renewables for space heating/cooling and for water heating (passive and active solar, geothermal), designing aspects, Installation of Heating, Ventilation and Air Conditioning systems.

Source: Elaborated by the authors.
Note: 'Daylighting' refers to allowing more indoor daylight into new or renovated buildings to reduce the need for electric lighting.

Select analytical approach.

Demand and supply projections are a basic input for the elaboration of scenarios and the subsequent financial assessment in the energy sector. These may be readily available from existing national development or energy plans or National Communications. However, in some cases they may need to be elaborated, for example to extend existing projections, for the specific timeframe of the financial assessment. This will necessarily call for an analytical approach.

The analytical approaches recommended for the financial assessment associated with energy mitigation options range from simple spreadsheet models that can be built by members of the project team to well-established energy models if they are already in use in the country. A combination of approaches, e.g., an energy-economic model supplemented with spreadsheet analysis, eventually with the help of costing tools, could also prove suitable.

Many energy models and costing tools have been widely used in countries in the context of national and global energy sector assessments which can also be used for a financial assessment (see Box 3.1 for examples).

Box 3.1

Some popular energy models and tools applied to the analysis of investments and costs in the energy sector

- The Energy and Power Evaluation Program (ENPEP), developed by Argonne National Laboratory and the International Atomic Energy Agency (IAEA)
- Market Allocation (MARKAL), developed in a collaborative effort under the auspices of the Energy Technology Systems Analysis Programme of the International Energy Agency
- Long-Range Energy Alternatives Planning System (LEAP), developed by the Stockholm Environment Institute
- Model of Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE), developed by the International Institute for Applied System Analysis
- Wien Automatic System Planning Package (WASP), developed by IAEA
- Model for Analysis of Energy Demand (MAED), developed by IAEA
- RETScreen, developed by Natural Resources Canada to evaluate various types of renewable energy and energy-efficient technologies
- HOMER, developed by the National Renewable Energy Laboratory
- CO2DB, a database containing detailed data on carbon mitigation technologies developed by IIASA
- Energy Costing Tool, developed by UNDP and the United Nations Millennium Project.

The models are often referred to as either “top-down” or “bottom-up” models, depending on how they treat energy fuels, technologies and markets and the rest of the economy.[4] Hybrid approaches, which utilize both “top-down” approaches and “bottom-up” approaches, are also used. Information from bottom-up studies, if available from previous assessments or sectoral analyses, is recommended for financial assessments due to their disaggregated information and their emphasis on energy fuels, technologies and markets, as well as their greater transparency compared to top-down models.

If an energy model is not suitable, a sectoral plan or a projection of trends can be used to create the scenarios. Energy ministries, regulatory agencies or electric utilities may have expansion or development plans for some part (e.g., electricity supply) or all of the energy supply system. These plans would be based on projections of energy demand in relevant end-use sectors.

[4] See, for example, Heaps, C. and Kollmuss, A. (2008). “UNFCCC Resource Guide for Preparing the National Communications of non-Annex I Parties. Module 4: Measures to Mitigate Climate Change.”

Step 2.

Compile historical IF, FF, O&M cost data (and subsidy cost data if included explicitly), and other input data for scenarios.

The collection of historical investment and financial flows and O&M cost information is key as a basis to create the baseline scenario for the finance assessment. Since investments may not occur every year and these flows and operating costs may be spread over long periods, the methodology recommends that countries compile ten years of historical investment and financial flows data, i.e., for the base year and the previous nine years to have a "sample decade" of how these flows were spread and the magnitudes involved. At a minimum, countries should collect at least three years of data (i.e., for the base year and two years during the previous decade).

Compile historical annual IF and FF data, disaggregated by investment entity and source.

Data should be compiled for each investment type (i.e., relevant technologies involved in current conditions and under mitigation options, e.g., thermal power plants, renewable power plants, etc.) and financial flows (i.e., all programmatic expenditures, such as expenditures associated with information campaigns or other public programmes, or industry programmes, e.g., on research and development and demonstration). Data should be annual, disaggregated by investment entity, and, if possible, by funding source; it should also be divided into investment flows and financial flows (see Chapter II, Table 2.3: 'Template for one year of historical investment and financial flows data').

The definitions of investment types, especially how narrow they are (e.g., combined cycle thermal power plant or simply power plant differentiated by fuel), will depend on the national circumstances, in particular to the relevance of specific technologies and mitigation options in the country, the sectoral scope chosen and the level of detail of the analytical approach.

The investment and financial flows data needed may reside in several locations (e.g., national accounts, national planning bodies or commissions and ministry records and plans, industry records, statistical agencies, utilities, research institutions, etc.). Note that sectoral and subsectoral scopes and disaggregation will vary among data sources, so expert judgement may be required to reconcile datasets and extract data needed from aggregated categories. For example, the United Nations System of National Accounts utilizes the International Standard Industrial Classification (ISIC) system in which energy supply activities are dispersed among four separate sections (the highest, or most aggregated, classification level).[5] Also, even at the most disaggregated level in the ISIC system, multiple energy activities are combined so disaggregating investment information for each activity will require expert judgement and/or using supplementary information.

It is recommended that local sources of sectoral data that can provide the most granular level of information (energy and industry ministries, industry associations and non-governmental organizations, for instance) or National Communications data be chosen instead of (aggregate) national accounts sources.

[5] The International Standard Industrial Classification of All Economic Activities (ISIC) is a United Nations system for classifying economic data. The latest version (ISIC Rev.4) is accessible at: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27.

Compile historical annual O&M cost data, disaggregated by investment entity and funding source.

Historical O&M data are also needed to provide a basis from which to project future O&M costs for new physical assets, as well as to provide input for the scenarios. Annual O&M costs for the physical assets in operation during the historical period should be collected (or estimated) for the same years for which historical investment and financial flows data are collected. Information about the expected lifetimes of the assets in operation during the historical period and annual fluctuations in O&M costs (if any) also need to be collected. O&M data should be collected at a level of disaggregation consistent with the investment and financial flows data, and the O&M data for assets purchased during the historical period should be tracked separately from the O&M data for assets purchased before the historical period (see Chapter II, Table 2.4: 'Template for three years of historical O&M cost data for an investment flow in 2023').

The O&M data may reside in one or more of the locations for investment and financial flows data (e.g., national accounts, ministry records and plans, industry records, statistical and regulatory agencies, utilities, research institutions). If such data are not available, countries should utilize one of the estimation approaches described in Chapter II (extrapolation, utilization of international sources and costing models, etc.).

Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment.

There are numerous types of energy subsidies, including direct financial transfers (e.g., grants and low-interest loans to producers), preferential tax treatments, trade restrictions, direct investment in energy infrastructure, demand guarantees and mandated deployment rates, price controls, market access restrictions and controls over access to resources. If a country chooses to include subsidies explicitly in the financial assessment, annual costs of subsidies for each type of investment during the historical period should be collected (or estimated) for the same years for which historical investment and financial flows data are collected. Subsidies should be compiled separately for IF, FF and O&M (see Chapter II, Table 2.5: 'Template for three years of historical subsidy cost data').

Information on subsidies may be available from relevant government ministries or agencies, statistical agencies, research organizations, academic institutions and private sector entities.

Compile other input data for scenarios.

In addition to historical investment and financial flows and O&M cost data, the characterization of the scenarios and annual costs for the scenarios will require the collection of other historical, current and projected data relevant to the sector.

Firstly, it will be important for the energy experts included in the team to provide general information on major sector and macroeconomic policies (both recent and expected) that impact energy supply and demand projections and energy costs.

Secondly, more data will be needed to project supply and demand for different subsectors. It is likely that additional data will be needed, such as those data described on page 15.

If the primary energy subsector is included, the below may be needed.

- Data to characterize primary energy supply, such as: contribution of fossil fuels/nuclear/renewables to total primary energy; details on fossil fuel domestic production, imports and exports; projections for primary sources over the assessment period; and, especially for renewables, an assessment of the potential for growth in supply.

If the electricity generation/distribution subsectors are included, the below may be needed.

- Inventory of and characterization of heat and power generation facilities. This includes the type of fuel/ energy source, technology type (e.g., combined cycle), operating costs, performance characteristics (e.g., fuel requirements, efficiencies), time schedule of retirement (or expected lifetime for each investment type considered), planned capacity additions (e.g., under national energy or development plans) and upgrades over the assessment period.

- Inventory and characterization of energy transformation facilities.

- Inventory and characterization of electricity and heat transmission/distribution infrastructure.

- Characterization of alternative higher efficiency and/or lower carbon heat and power generation technologies, including information about operating costs and performance characteristics.

- Characterization of other energy supply mitigation measures (e.g., measures to reduce transmission and distribution losses of electricity), including information about operating costs and performance characteristics.

If the energy end-use subsectors are included, the below may be needed.

- Characterization of energy end-use demand by fuel/energy carrier type and by end-use sector, including information on drivers of growth (e.g., demographic change and urban development), domestic demand forecasts and, for those countries that have significant export industries for fossil fuels, refined products or electricity, demand forecasts in neighbouring countries or international markets.

- Characterization of alternative higher efficiency and/or lower carbon end-use technologies (e.g., high efficiency passenger vehicles, high efficiency industrial motors, passive and active solar water heaters, high efficiency cook stoves), and of higher efficiency end-use infrastructure (e.g., public transport, improved building design) including information about operating costs and performance characteristics.

Step 3.

Define baseline scenario.

This step entails projecting each selected energy supply and/or energy end-use subsector over the assessment period, assuming that no new or scaled up policies to address climate change are implemented. It should reflect current macroeconomic conditions, sectoral and national plans and their ongoing implementation, expected socioeconomic trends and expected investments in the subsectors. The baseline scenario may be based on a model, a sectoral plan, a projection of trends or some combination, including projections and actual investment and financial flows (e.g., between 2025 and 2028), if available. In addition to specific information about how both energy supply and demand are expected to evolve over the assessment period, the baseline scenario description should include specific information about facility and infrastructure investments that are expected in each subsector (e.g., the timing and magnitude of capacity additions in the power sector for each investment type selected), as well as programmatic investments (e.g., the timing, nature and magnitude of an energy research and development and public or private or mixed programme).

Step 4.

Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the baseline scenario.

Identify annual IF and FF for each investment type, disaggregated by investment entity and funding source.

In this step, annual investment and financial flows for facility and infrastructure for the baseline scenario are projected for each subsector. IF should be detailed per investment type (e.g., purchase or incremental investment in a given type of equipment) or FF type (e.g., given type of programmatic expenditure, such as costs of a research and development and demonstration programme). As discussed in Chapter II, investment and financial flows should be measured in real terms (i.e., deflated and presented in constant 2025 national currency or US$[6]), reported in the year in which they are expected to be incurred and, for cumulative calculations, they should be discounted using appropriate public and private discount rates. Furthermore, annual IF (purchase and improvement of durable goods) and FF (programmatic expenditures) data should be disaggregated by investment entity and funding source. Data would be obtained either using models or other projection tools, and/or government and private sector planning documents, or might be derived from historical data.

The output of this step will be a stream of annual investment flows and/or financial flows for each investment or financial flow type (defined generically in terms of technology/fuel, type of programme, etc.) and subsector for the entire assessment period. Output will also include data on the investment entities involved (e.g., private sector utilities at aggregate level or public sector) and funding source. These data should be organized as in Chapter II, Table 2.6: 'Baseline scenario: *cumulative* investment and financial flows and O&M' and Table 2.7: 'Baseline scenario: *annual* investment and financial flows and O&M.'

[6] Deflated values of a variable (such as annual IF data) are typically calculated by correcting the nominal value of the variable in a given period t (e.g. ift). To do this the nominal value ift is multiplied by the relevant base year price index (e.g. P2025) and it is divided by the price index of the corresponding year (i.e. Pt). For example, real IF for year t is given by IFt = ift . $\left(\frac{P_{2025}}{P_t}\right)$. The relevant price index is the one customarily used for deflating energy sector data (e.g. service or utilities price index, wholesale, etc.)

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

Annual values of O&M costs for assets purchased during the assessment period, and for assets purchased before the assessment period and that are expected to still be in operation, need to be collected (or derived) for each selected subsector. Costs should be reported in real terms, in constant 2025 US$ or national currency, should be reported in the year in which they are expected to be incurred and should be discounted. The annual O&M values for each investment type should be disaggregated by investment entity and funding source (as in Table 2.4 in Chapter II: 'Template for three years of historical O&M cost data for an investment flow in 2025') and be divided into O&M for assets purchased during the assessment period and for assets purchased prior to the assessment period. For those assets purchased during the assessment period that are expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be identified, up to an additional five years after the end of the assessment period. Possible data sources include those described above for IF and FF, notably local sources (sectoral plans and projections, National Communications and eventually national accounts) and international sources (costing data and tools).

If subsidies are included explicitly in the assessment, identify annual subsidy costs for each investment type and IF, FF and O&M costs.

If a country chooses to include subsidies explicitly in the financial assessment, annual subsidy costs should be identified for each relevant investment type and for all categories of cost (IF, FF and O&M) in the baseline scenario (see Chapter II, Section 2.2.1).

Step 5.

Define target scenario.

This step entails developing a description of what is likely to occur in each selected energy supply and energy end-use subsector over the assessment period if new and additional mitigation efforts are implemented to address climate change, based on the national target that is being assessed (e.g. NDC, LT-LEDS). This would include comprehensive descriptions of the specific mitigation measures that would be implemented (technology types, implementing subsectors, etc.), and the implications of those measures for the evolution of the subsectors (e.g., a reduction in capacity needed in the power sector due to electricity savings in the industry and the buildings sector).

The mitigation measures need to be defined clearly and completely so that IF, FF and O&M costs can be identified in the next step. This should include specific information about facility and infrastructure investments that would occur in each subsector (e.g., the timing and magnitude of facility upgrades and capacity additions in the power sector by technology type, the timing, number and characteristics of more efficient end-use equipment, etc.), as well as programmatic investments (e.g., the timing, nature and magnitude of a renewables research and development programme). An adjusted sectoral plan, a projection of trends or a combination can be used as the basis of the projection. Prior work on climate change (e.g., National Communications, technology needs assessments, GHG mitigation assessments) should be utilized in this step.

Countries should assess qualitatively the GHG and non-GHG benefits and potential non-investment costs (negative externalities) of the mitigation measures.

Non-GHG benefits to consider could include those described below.

- Sales revenues: Investments in energy supply facilities and in end-use facilities and infrastructure that produce goods or services (e.g., public transport systems) will accrue sales revenues, which can significantly (or more than) offset investment and operating costs.
- Energy security: Mitigation measures that enhance domestic energy supplies (e.g., development of renewable energy technologies) can increase national energy security and/or decrease dependency on energy imports.
- Reduced air pollutants: Switching to lower carbon-content fossil fuels or to renewables or nuclear energy and utilizing fossil energy more efficiently can significantly reduce air pollutants, with consequent benefits to both human and ecological health.

Negative externalities could include those described below.

- Damages from hydropower development: Hydropower projects can disrupt ecosystems upstream and downstream from facilities and the filling of reservoirs can displace settlements.
- Increased competition for resources: Increasing agricultural and woody biofuel supply can increase demand for productive lands and exacerbate existing land availability constraints. Thermal electricity and heat generation plants (which require significant quantities of water for cooling) and hydroelectric facilities can reduce water supply.
- Emissions leakage: Switching to a lower carbon fossil fuel (e.g., coal to gas) for combustion may inadvertently result in higher fugitive emissions depending on fuel characteristics and fuel production and transport operations. Hydropower reservoirs can result in additional CH_4 emissions due to anaerobic decomposition of organic material in floodwaters.

The criteria used to select the pecking order of priority measures should be clearly explained or specified (e.g., through a simple multi-criteria analysis table where each measure is given a grading normalized to a range 0-10). It is also recommended to present the results from these qualitative assessments in a specific section in the sectoral financial assessment report.

Step 6.

Identify annual IF, FF, O&M costs (and subsidy costs if included) for the target scenario.

Identify annual IF and FF for each investment type, disaggregated by investment entity and funding source.

In this step, annual IF for the target scenario facility and infrastructure investments and annual FF for the target scenario programmatic investments are identified for each subsector. As discussed in Chapter II, costs should be in real terms (i.e., inflation adjusted), in constant 2025 national currency or US$, should be reported in the year in which they are expected to be incurred and should be discounted using appropriate public and private discount rates. The annual investment and financial flow values for each investment type should be disaggregated by investment entity and funding source and be divided into investment flows and financial flows. Data sources could include model output, and/or government and private sector planning documents or values might be derived from historical data.

The output of this step will be a stream of annual investment flows and/or financial flows for each investment type in each subsector for the entire assessment period, by investment entity and funding source. These data should be organized as in Chapter II, in Table 2.8: 'Target scenario: *cumulative* investment and financial flows and O&M' and Table 2.9: 'Target scenario: *annual* investment and financial flows and O&M.'

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

Annual values of O&M costs for assets purchased during the assessment period and for assets purchased before the assessment period and that are expected to still be in operation need to be collected for each subsector. Costs should be in real terms, in constant 2025 national currency or US$, should be reported in the year in which they are expected to be incurred and should be discounted. The annual O&M values for each investment type should be disaggregated by investment entity and funding source (as in Chapter II, Table 2.4: 'Template for three years of historical O&M cost data for an investment flow in 2023') and be divided into O&M for assets purchased during the assessment period and for assets purchased prior to the assessment period. For those assets purchased during the assessment period that are expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be identified, up to an additional five years after the last year of the assessment period. Possible data sources include those described above for IF and FF.

If subsidies are included explicitly in the assessment, identify annual subsidy costs for each relevant investment type and for IF, FF and O&M costs.

If a country chooses to include subsidies explicitly in the financial assessment, annual subsidy costs should be identified for the investment and financial flows and O&M costs of each relevant investment type in the baseline scenario (see Chapter II, Section 2.2.1).

Step 7.

Calculate the changes in IF, FF and O&M costs (and in subsidy costs if included explicitly) needed to implement target scenario.

The changes in IF, FF and O&M costs needed to implement the target scenario are calculated in this step by subtracting baseline scenario costs from target scenario costs. Given the scenario information has been collected broken down by investment entities and broken down by different years, this step determines: 1) how *cumulative* investment and financial flows and O&M costs would change; and 2) how *annual* investment and financial flows and O&M costs would change. These calculations are described in Chapter II.

Step 8.

Identify policy implications.

The purpose of this step is to identify the policy implications of the assessment results for the sector. The analyses in the previous step provide an indication of the magnitudes and timing of changes in investment and financial flows and O&M by each investment entity and from each funding source that would be needed to implement the target scenario. These results should be supplemented by information regarding the implementation and financial feasibility of the target scenario and the policies that may help in this direction.

Looking at the resulting required financial shifts and increases, which type of investment entities (e.g., public utilities, private firms or state agencies at this aggregate level) are responsible for the most significant (largest and/or highest priority) changes in investment and financial flows (i.e., incremental IF and FF) need to be identified, as well as the predominant sources and potential limitations of their funds.

The feasibility of meeting these additional financial needs and the compatibility between the implementation of priority measures and national development and sector plans should be discussed, particularly in view of ongoing policies and measures.

Policies and incentives should be identified to induce entities to implement the proposed measures and to change their investment patterns to reach the required financial shifts and increases to implement the target scenario, as well as to mobilize additional funds to meet new investment needs. It is important to distinguish between public and private and between domestic and foreign sources of additional finance.

Policy measures include a variety of instruments, including economic instruments (e.g., taxes), regulatory instruments (e.g., fuel portfolio standards), voluntary agreements, information dissemination and other instruments (e.g., research, development and demonstration programmes) (see Table 3.2 below). The suitability and acceptability of different instruments and policy initiatives to advance implementation of the priority mitigation measures should be discussed with decisionmakers.

Table 3.2: Potential policy options to encourage GHG mitigation in the energy sector

Policy objectives	Policy options				
	Economic instruments	**Regulatory instruments**	**Voluntary agreements**	**Dissemination of information and strategic planning**	**Technological research, development, demonstration and deployment**
Energy efficiency	Higher energy taxes Lower energy subsidies Power plant GHG taxes Fiscal incentives Tradable emissions permits	Power plant minimum efficient standards Best available technologies prescriptions	Voluntary commitments to improve power plant efficiency	Information and education campaigns	Cleaner power generation from fossil fuels
Energy source switching	GHG taxes Tradable emissions permits Fiscal incentives	Power plant fuel portfolio standards	Voluntary agreements to fuel portfolio changes	Information and education campaigns	Increased power generation from renewable, nuclear and hydrogen as an energy carrier
Renewable energy	Capital grants Feed-in tariffs Quota obligation and permit trading GHG taxes Tradable emissions permits	Targets Supportive transmission tariffs and transmission access	Voluntary agreements to install renewable energy capacity	Information and education campaigns Green electricity validation	Increased power generation from renewable energy sources
Carbon capture and storage	GHG taxes Tradable emissions permits	Emissions restrictions for major point source emitters	Voluntary agreements to develop and deploy Carbon Capture and Storage	Information campaigns	Chemical and biological sequestration Sequestration in underground geological formations

Source: Bert Metz, *et al.* (eds.) (2007) "Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" Cambridge University Press, Cambridge.

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