



United Nations Climate Change
Paris Committee on Capacity-building



Global Energy Interconnection
Development and Cooperation Organization
全球能源互联网发展合作组织



iha
international hydropower association

Building Capacity on New Power System for Global Energy Transition and Global Climate Action

Host : GEIDCO

Co-host : UNFCCC IHA

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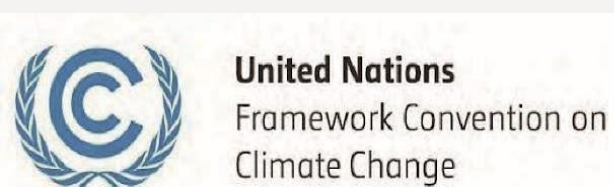


Compendium on GHGs Baselines and Monitoring: Energy Sector

Global Energy Interconnection Development and Cooperation Organization

Economic and Technology Research Institute

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I. Capacity Building on Energy

Mitigation

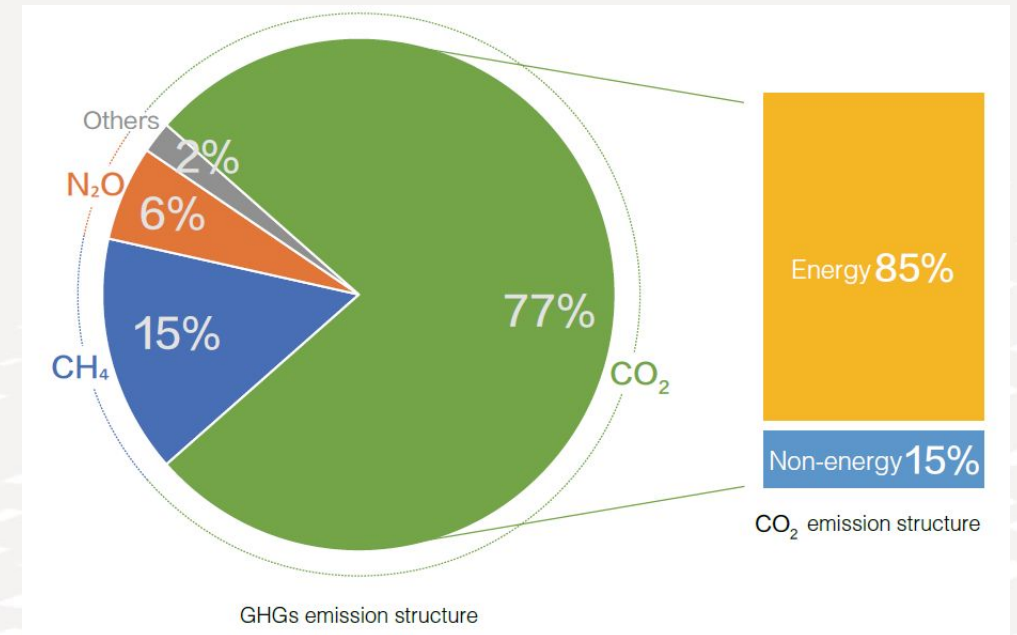
II. Energy Emission Accounting Method

III. Policy and Implementation Mechanisms

1.1 Emission Accounting Method

The total global GHGs emissions are continuously rising, with fossil fuel combustion being the primary source. Therefore, the key for controlling CO₂ emissions lies in the energy sector.

- The global GHGs emissions are continuously rising . Since the mid-20th century, with the rapid growth of the global economy and population, GHGs have increased from 39 Gt CO₂e in 1990 to 57 Gt CO₂e in 2022.
- Fossil fuel emissions are the main source . CO₂ emissions related to fossil fuel use account for more than 85% of total CO₂ emissions, with the proportion increasing each year. Therefore, controlling CO₂ emissions related to fossil fuels is central and crucial for emission reductions in the energy sector.



Global GHGs emissions and structure

1.2 Introduction of the Compendium

The UNFCCC capacity-building assessment report indicates that developing countries face common challenges and difficulties in the energy sector regarding emissions reduction, such as weak data foundations, limited capacity building, and difficulties in policy implementation. The accounting methods for GHGs emissions and mitigation actions play a crucial role in enhancing the capacity of developing countries.

Therefore, to strengthen the capacity of developing countries in the energy sector, GEIDCO, UNFCCC and UNEP, jointly compiled this compendium. It aims to provide technical guidance for policymakers in developing countries on emission accounting, scenario designing and policy framework in the energy sector.

能源部门温室气体
排放核算方法及
监测指南

COMPENDIUM ON
GREENHOUSE GAS
BASELINES AND
MONITORING

ENERGY SECTOR



I. Capacity Building on Energy
Mitigation

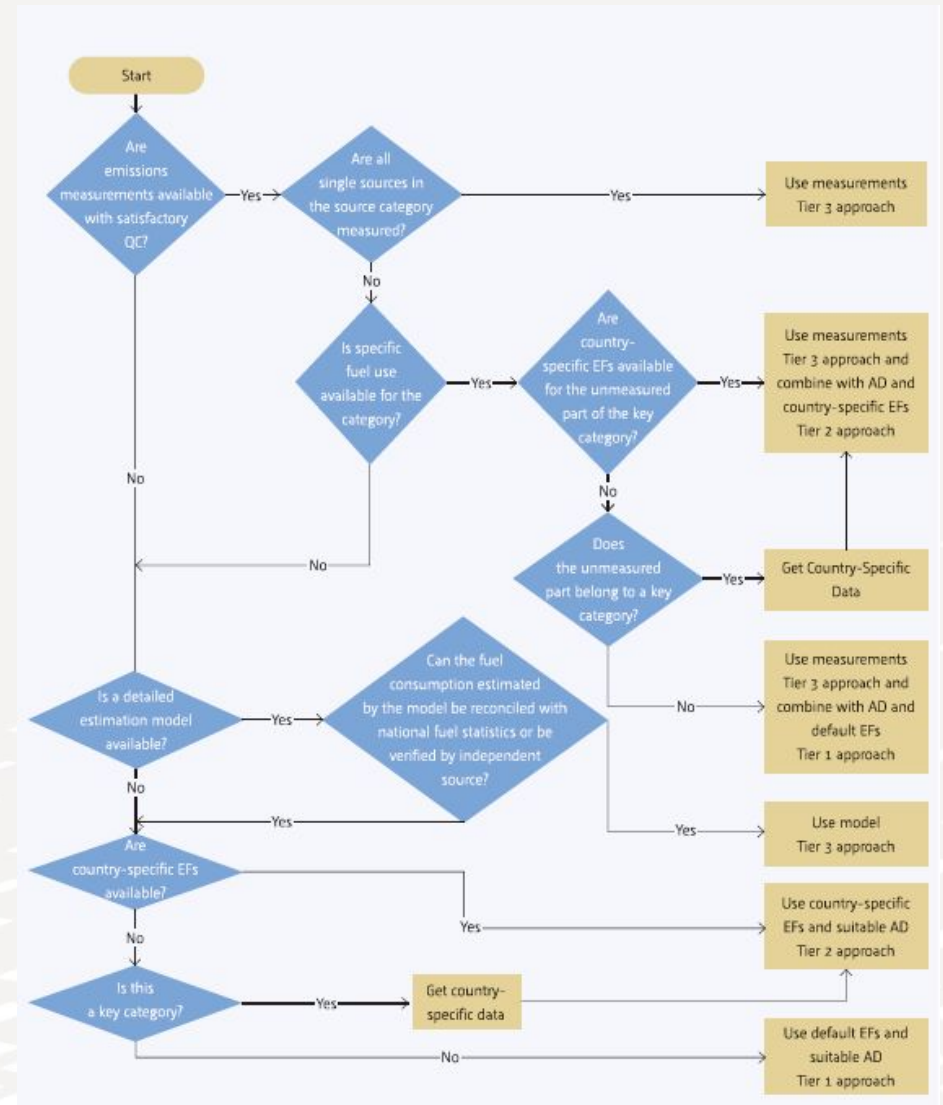
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2.1 Emission Accounting Method

GHG emission accounting provides an essential data foundation for countries to formulate GHG reduction targets. Developing countries should follow standard methods and guidelines for GHG emissions accounting, meanwhile choose method at different complexity level considering their actual development situations.

It is necessary to define the scope of accounting for the energy sector, provide accounting methods for different scenarios, clarify the requirements for preparing emission inventories, and offer implementation recommendations for countries compiling their GHG inventories.



Decision tree for stationary emissions

2.1 Scope of Accounting

The scope of accounting in the energy sector includes four stages: energy production, processing and transformation, transmission and distribution, and energy consumption. There are two types of emission: stationary combustion emission and fugitive emission.

- **Energy Emission Stages**

- **Production** : Refers to the exploration and extraction of primary energy sources, such as coal mining, and oil and gas exploration and extraction processes.
- **Processing and Transformation** : Refers to converting primary energy into other usable energy forms, such as power generation, heating, crude oil refining, and natural gas processing.
- **Transmission and Distribution** : Refers to the transmission and distribution of primary and secondary energy, including the transmission and distribution of fossil fuels and electricity.
- **Consumption** : not included in this report.

- **Two Types of Energy Emissions**

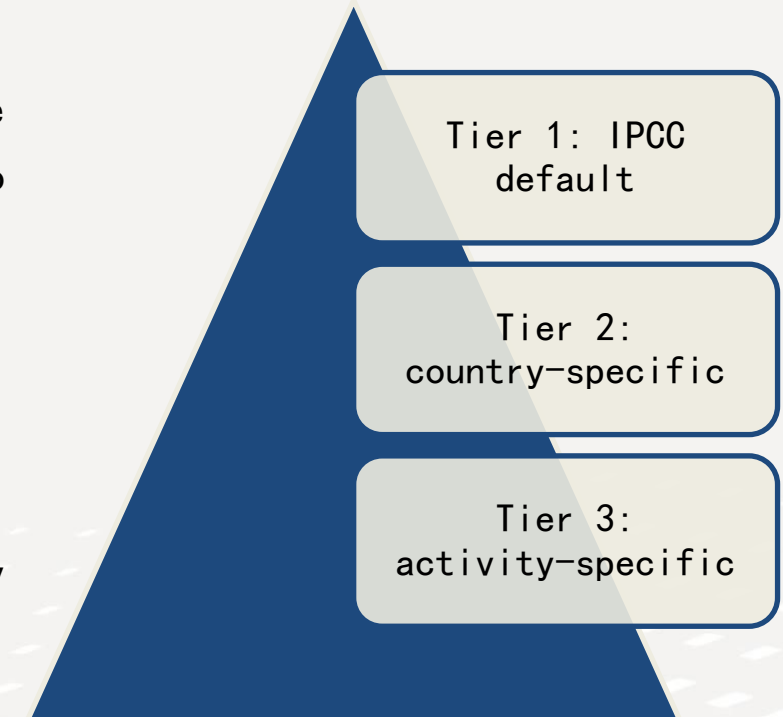
- **Stationary Combustion** : Refers to emissions generated from the combustion of fuels in energy extraction or energy production industries.
- **Fugitive Emissions** : Includes all emissions that occur during fuel extraction, processing, storage, and transportation to the final point of use.

Emission type	Activities	Description
Combustion emissions (stationary combustion)	Electricity and heat production	Emissions from electricity generation, combined heat and power generation, and heat plants ¹ .
	Other energy industry	Combustion emissions arising from the energy-producing industries' own (on-site) energy use. This includes the emissions from own-energy use from coal mining, oil and gas extraction and the processing and upgrading of natural gas.
Fugitive emissions	Other energy industry	Fugitive emissions from the extraction, processing, storage and transport of fuel to the point of final use for coal, oil and gas systems

2.1 Accounting Methods

Three Tier approaches for the emission factors and activity data

- **Tier 1** approach requires that countries choose from a global average range of emission factors and use country-specific activity data to calculate total emissions.
- **Tier 2** approach uses country- or basin-specific emission factors that represent the average values for the coals being mined.
- **Tier 3** approach uses direct measurements on a mine- or plant-specific basis, therefore has the highest data quality requirement and lowest level of uncertainty.



$$Emissions_{GHG, fuel, technology} = Fuel Consumption_{fuel, technology} * Emissions Factor_{GHG, fuel, technology}$$

where:

Emissions_{GHG, fuel, technology} = emissions of a given GHG by type of fuel and technology (kg GHG)

Fuel Consumption_{fuel, technology} = amount of fuel combusted per type of technology (TJ)

Emission Factor_{GHG, fuel, technology} = emission factor of a given GHG by fuel and technology type (kg GHG/TJ)

Three tiers of emission accounting methods

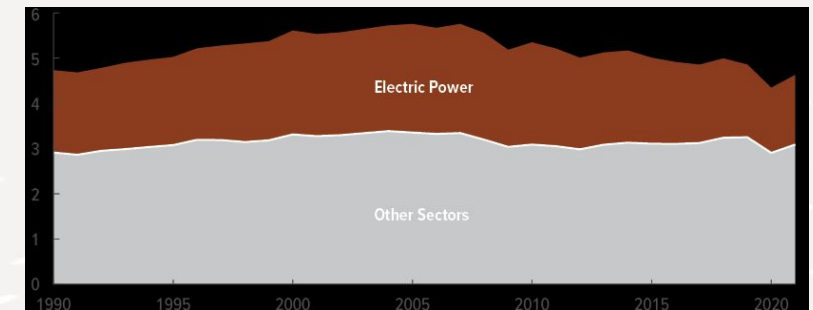
2.2 Application for Main Sectors

1 Power and heat production

Emissions from power and heat production are the main sources of emissions in the energy sector, accounting for about 38%. Emissions mainly come from fossil fuel combustion and desulfurization processes.

□ Power generation:

- Determine the types of fossil fuels and activity levels, including the consumption and lower heating values of coal, oil, and gas.
- Establish emission factors for different types of fuels and units, such as CO₂, CH₄, and N₂O.
- CO₂ emissions from the desulfurization process in coal-fired units = consumption of carbonates × emission factor.



Total Emissions of Carbon Dioxide From the Electric Power and Other Economic Sectors

2.2 Application for Main Sectors

2

Fossil fuels mining

Emissions during the extraction, processing, transformation, transportation, and use of coal, oil and gas primarily include combustion-related emissions and fugitive emissions, with CO₂ and CH₄ as the main GHGs.

■ Coal Mining and Processing Transformation

- **Combustion Emissions** : Emissions generated during mining operations, as well as flaring emissions of methane.
- **Fugitive Emissions** : Include emissions from gas released during coal seam fracturing in mining operations, low-temperature oxidation emissions, and uncontrolled combustion emissions from fires.

■ Oil and Gas Extraction and Processing

- **Transformation Combustion Emissions** : include well operations, field gathering and transportation, and transmission processes, as well as combustion treatment in flaring systems for waste gas.
- **Fugitive Emissions** : Account for CH₄ or CO₂ gases intentionally released into the atmosphere through process vents or safety valves at various stages of production.



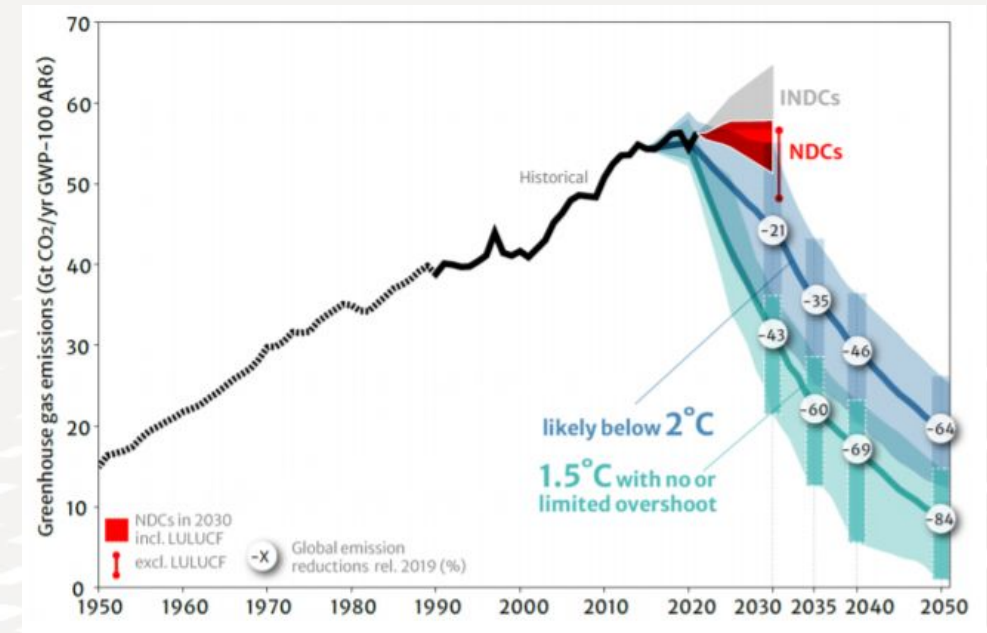
Flaring systems for waste gas

2.3 Setting Scenarios

Scenario design is an important research tool for countries to submit nationally determined contributions (NDCs), formulate their own mitigation strategies, and implement mitigation action plans. This provides scientific support for governments to set mitigation targets, determine reduction pathways, and establish policy frameworks.

■ The formulation process is divided into five steps:

- Defining analysis objectives.
- Establishing baseline scenario.
- Creating mitigation scenario.
- Calculating mitigation potential.
- Monitoring, reporting and verification.

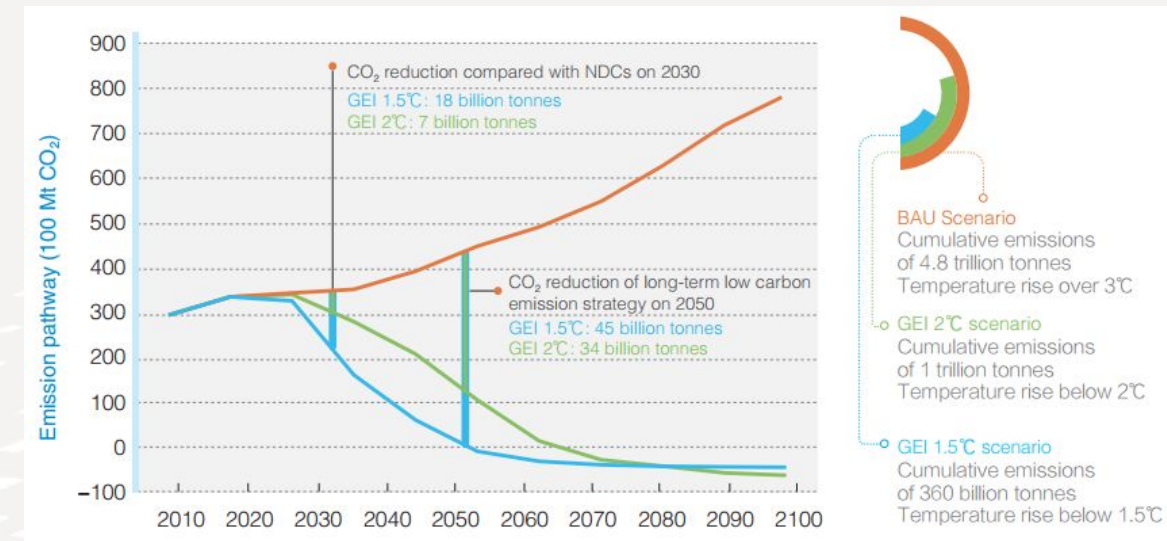


NDC and 2/1.5 °C mitigation pathways

2.3 Mitigation Potential Assessment

After determining the baseline scenario and the mitigation scenario, the mitigation potential can be analyzed by comparing the two scenarios. This allows for the calculation of mitigation costs, the determination of the comprehensive benefits and an analysis of the implementation challenges of the mitigation plan.

- **Analyze mitigation potential** : Calculate the cumulative emission reduction and assess the mitigation gap.
- **Calculate mitigation costs** : Evaluate the investment in the energy system and calculate the marginal mitigation cost.
- **Assess comprehensive benefits** : Evaluate the economic value, social value, and environmental value.
- **Implementation challenge analysis** : Consider factors such as market structure and complexity, carbon lock-in effects, energy security, fairness and social welfare, unemployment, and competitiveness.
- **Data Sources, Uncertainty, and Sensitivity Analysis**

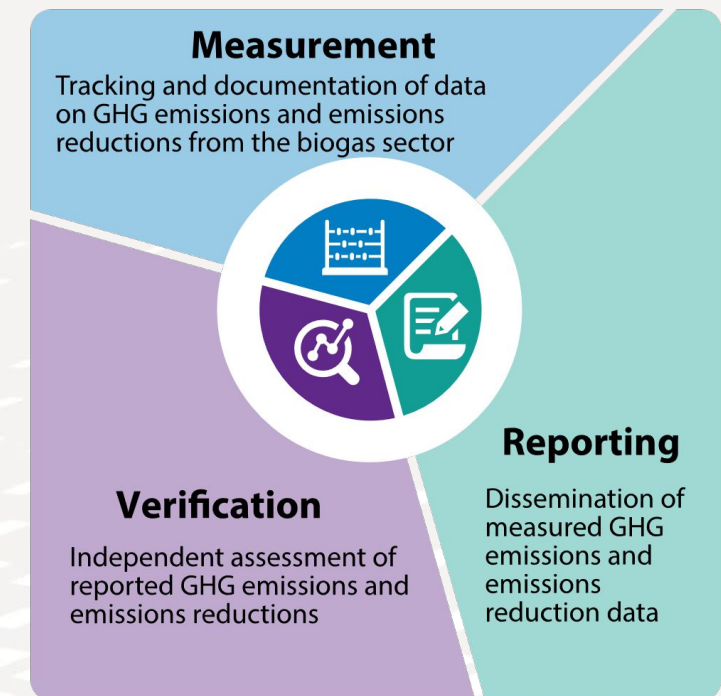


Mitigation Pathways of GEI Scenarios

2.4 Reporting and Transparency

Based on the accounting scope and methods, each country prepares its national GHGs emissions inventory to fulfill its reporting obligations under the Paris Agreement. This enables countries to accurately track GHGs emissions data. Through the measurement, reporting and verification (MRV) mechanism, the transparency mechanism for carbon emissions and reductions is established, continuously strengthening national accounting methods and data monitoring capabilities.

- **Regularly Update Emission Inventory Reports** : Submitting an updated GHGs inventory report every two years is an important measure for implementing the Paris Agreement.
- **Enhance Transparency of Emission Inventories** : By improving emission inventory accounting, countries can strengthen their data foundation, accounting capabilities, and transparency.
- **Develop Scientifically Effective Mitigation Measures** : Based on inventory reports, identify mitigation areas and develop relevant measures.
- **Emphasize Data Organization and Preservation** : Record and store all accounting information to ensure transparency of accounting methods in the report and traceability of data.



Measurement, Reporting and Verification (MRV)



I. Capacity Building on Energy

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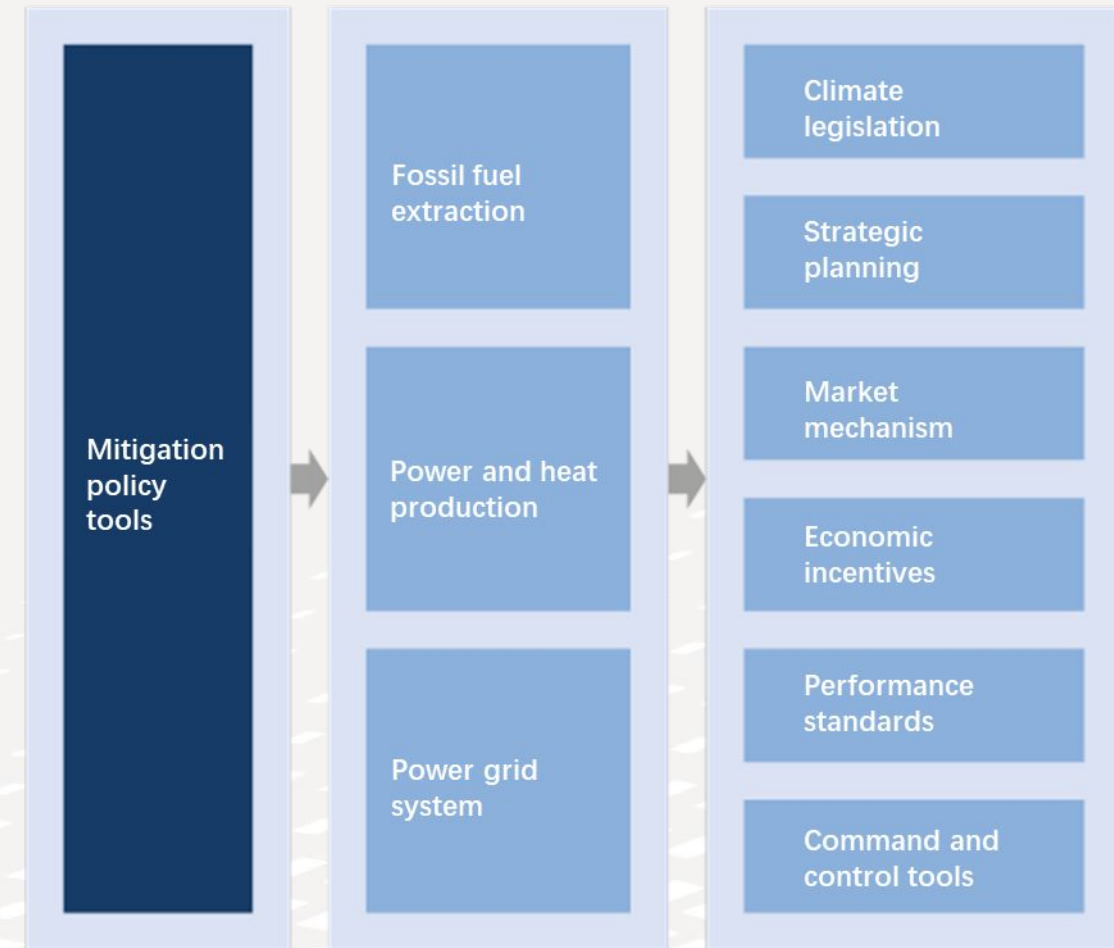
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3.1 Mitigation Policy Framework

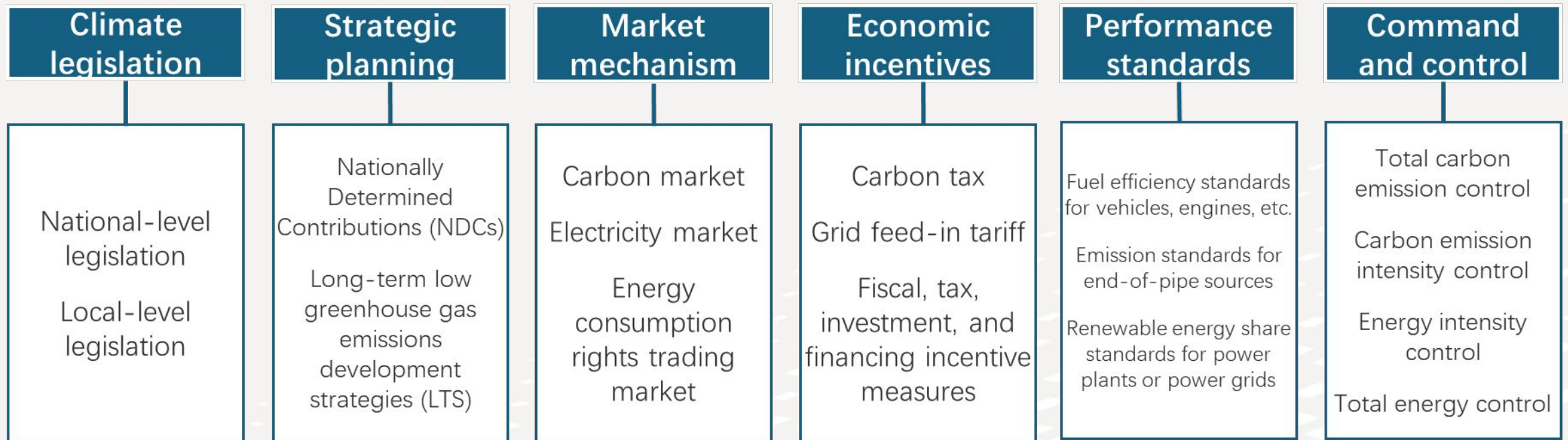
Decision-makers in developing countries should formulate comprehensive and integrated clean and low-carbon development strategies for the energy sector. These strategies should be tailored to regional, national, and local conditions.

The report establish the policy framework for the energy sector, outlining six main types of mitigation policy tools. And it focus on three key areas: fossil energy extraction, power and heat production, and power grid transmission.



3.1 Mitigation Policy Framework

There are six types of mitigation policy tools, including: climate legislation, strategic planning, market mechanism, economic incentives, performance standards, command and control tools.



3.1 Mitigation Policy Framework

1 Climate legislation

- **Application:** The UK's *Climate Change Act* of 2008 was the first legal framework established at the national level. More than 60 countries worldwide have since enacted climate legislation.

2 Strategic Planning

- **Application:** The UNFCCC and the Paris Agreement require each country proposing Nationally Determined Contributions (NDCs) and developing long-term low GHGs emission development strategies for the mid-21st century.

3 Market Mechanism

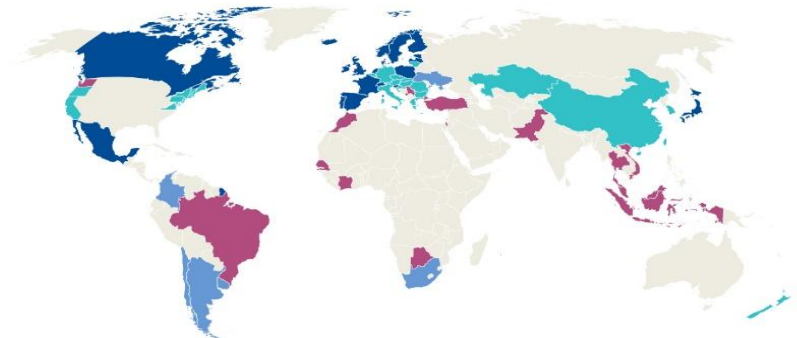
- **Application:** More than ten countries and regions, including the European Union, China, and the United States, have established carbon markets and are conducting carbon emissions trading.

China's National Carbon Market

- **Feature:** cover 5 Gt CO₂, 40% of national total, world largest ETS market.
- **Sector:** only include power sector, plan to expand to other sectors.
- **Institutions:** emission data accounting, reporting and verification, quota allocation and surrendering, trading and market supervision.

Carbon price choices

Countries and states are choosing different approaches to carbon pricing based on their own circumstances and objectives.



Source: WBG, IMF staff calculations, and national sources. Note: The boundaries and other information shown on any maps do not imply on the part of the IMF any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.

3.1 Mitigation Policy Framework

4 Economic Policy

- **Application:** Economic incentive policies include carbon taxes, feed-in tariffs, investment in infrastructure, subsidies for low-carbon technologies, as well as fiscal and financial incentives such as green bonds and low-interest loans.

5 Performance Standards

- **Application:** For example, setting an indicator for the share of non-fossil energy in primary energy supply within the energy structure. In California, the emission performance standard for power plants is set at 0.5 tons of CO₂ per MWh.

6 Administrative Measures

- **Application:** China's dual control policy on energy sets total energy consumption and energy intensity per unit of GDP as binding indicators within the local government performance evaluation system.

Coal-to-biomass transformation of coal-fired power generation units in Europe

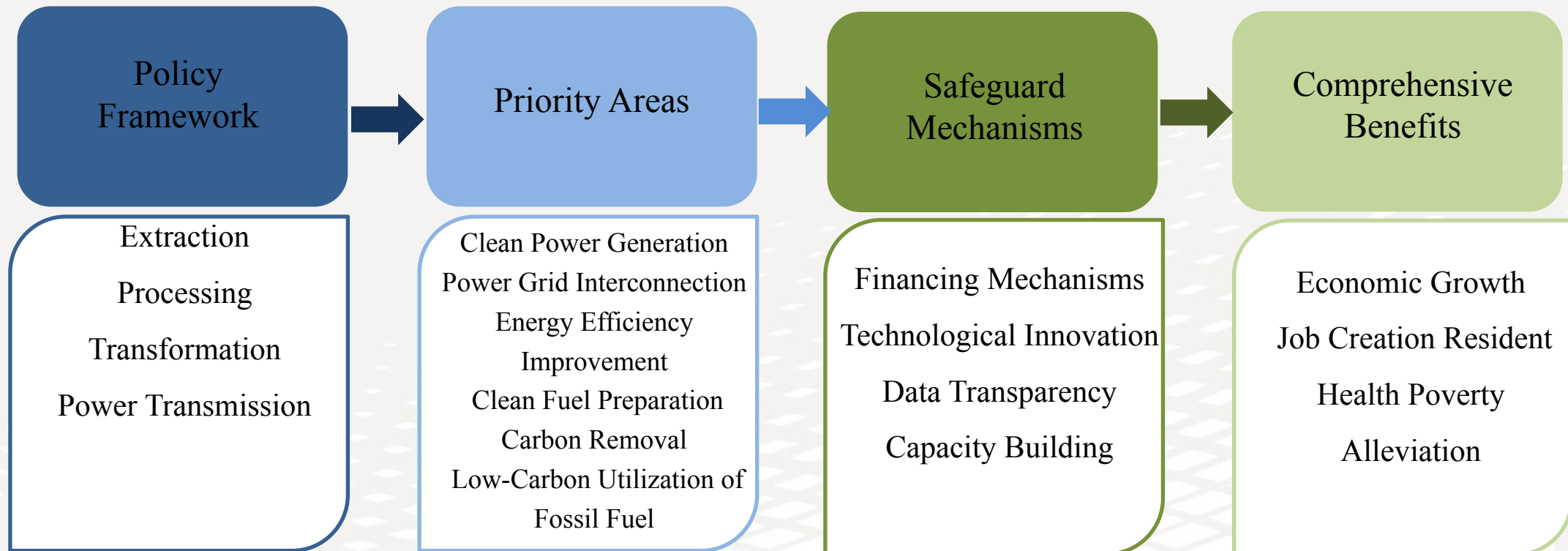
Drax Power Station (UK)

- **Technology:** 100% coal-to-biomass replacement
- **Scope:** four 6.6GW coal-fired power generation units.
- **Benefits:** zero-carbon transition of coal-fired power generation.



3.2 Implementation Mechanism

To achieve mitigation in the energy sector, it is necessary to formulate a policy framework at the national level, establish a safeguard mechanism, promote the implementation of mitigation actions in priority areas, tap into greater potential for mitigation, create comprehensive benefits, and promote the synergy between mitigation and sustainable development goals.



3.2 Priority Mitigation Actions

1 Clean Energy Development

- **Widely deploy clean energy to reduce emissions from the power system.** The cost of clean energy is dropping rapidly. Clean energy generation technology is mature and has cost advantages. The transition paths suitable for different countries vary, with developing countries needing to use renewable energy according to local conditions.

2 Low-Carbon Utilization of Fossil Energy

- **Emission reduction in the extraction, processing and conversion phases.** Improve extraction efficiency, reduce methane leaks in all stages of extraction, collection, processing, transportation, storage, and distribution, further strengthen the recovery and utilization of vented natural gas and associated gas from coal fields, and gradually reduce conventional flares.

3 Energy Efficiency Improvement

- **Promote the development of energy-saving technologies.** Technological innovation and widespread adoption can meet energy demands with lower energy consumption, including smart grids, smart homes, energy-saving lighting, etc, to enhance the energy efficiency. .

Inner Mongolia Wind-PV-Thermal Power Plant Project

- **Feature:** wind-PV-thermal power complement.
- **Industry:** attracting enterprises of PV industry chain.
- **Benefits:** 17,000 job opportunities for local people, and energy, industry, society and environment sustainable development.



3.2 Priority Mitigation Actions

4

Power Grid Interconnection

- Power grid interconnection achieves the optimal allocation of clean resources. The interconnection of energy networks is a prerequisite and foundation for accelerating the clean energy and electrification, and promoting the green and low-carbon transition of energy system. Ultra-high voltage (UHV) power transmission technology is the key to power grid interconnection.

5

Electrification and Clean Fuel Development

- Promote electricity access in remote areas. Implement electricity access actions in remote and small island areas, aiming to completely solve the issue of the unelectrified population by 2035. In the long-run, develop green hydrogen and other clean fuel production technologies.

6

Carbon Removal

- Carbon removal is an important supplementary means for carbon mitigation. It mainly includes various technological routes and models such as CCS, BECCS, and CCUS. Currently, there are over 400 CCUS projects globally, with 43 large-scale comprehensive projects above 400,000 tons.

Ethiopia-Kenya DC Transmission Project, provide cross-border trading of clean energy

Ethiopia-Kenya DC Transmission Project

- Technology: $\pm 500\text{kV}$ DC transmission.
- Main indicator: transmission capacity 2GW.
- Construction: **SGCC**, with a total length of 1045km.
- Benefits: 2700 job opportunities for local people.



3.3 Facilitation Mechanisms

1 Improve Funding Mechanisms

- Carbon pricing policies such as Emissions Trading Schemes (ETS), green certificates, Feed-in Tariffs (FIT) will help promote the development of renewable energy and reduce the cost of carbon emission reduction;

2 Promote Technological Advancement

- Increase R&D expenditure; Promote technology transfer to developing countries.

3 Strengthen International Cooperation

- International cooperation mechanisms include the CDM, GCF and GEF, can address the challenges on investment mobilization, capacity building, data acquisition, etc;

4 Improve Data Transparency

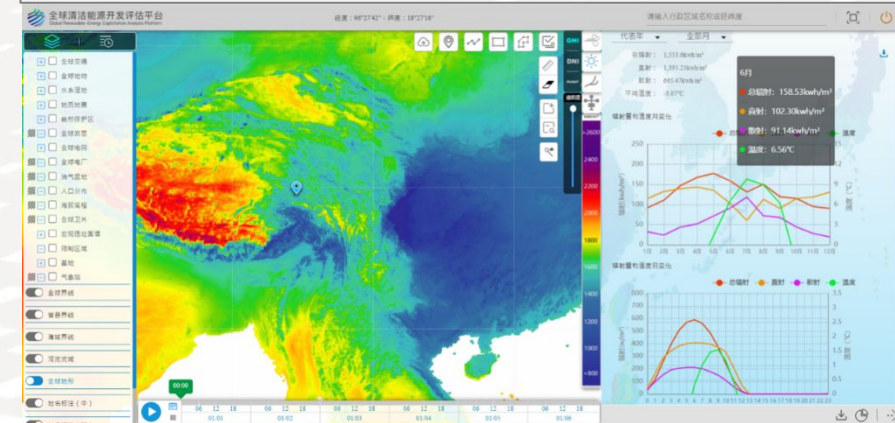
- There is an urgent need to build and improve the Monitoring, Reporting, and Verification (MRV) system and the Enhanced Transparency Framework (ETF) established under the Paris Agreement.

5 Enhance Capacity Building

- The Paris Committee on Capacity Building (PCCB) can support capacity building in developing countries.

Global Renewable Energy Assessment Platform (GREAN) platform by GEIDCO

- Features:** carrying out theoretical, technical and economic potential installed capacity of **hydro, wind and solar** energy from a global perspective.
- Site selection:** planning and site selection of 35 hydropower bases, 94 wind power bases and 90 PV bases.
- Grid planning:** provide global power grid data, with the voltage above 110kV in 147 countries.



3.4 Comprehensive Benefits

Promoting the implementation of mitigation projects in priority areas requires considering both energy transition and mitigation effectiveness, as well as assessing the synergistic benefits, including economic development, employment, equality, environment, health, and the other 17 sustainable development goals.

Various mitigation actions' synergies(+) and trade-offs(-)

Mitigation Actions	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
Clean energy generation	+	+/-	+/-	+	+	+/-	+	+	+/-	+	+	+	+	+/-	+/-	+/-	+
Interconnection	+	+	+	+	+	+	+/-	+	+	+	+	+	+		+/-	+	+
Efficiency improvement	+		+			+			+		+	+	+	+	+		
Clean fuel promotion	-		+/-				+/-	+	+	-	+		+				
Carbon removal			-			+/-	+	-	+				+				
Low carbon utilization of fossil fuels	+		+	+		+	+/-	+	+	+	+		+		+		+

Source: IPCC, 2018

Epilogue



United Nations
Framework Convention on
Climate Change



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Development and Cooperation Organizat
全球能源互联网发展合作组织



GLOBAL SUPPORT
PROGRAMME

Addressing climate change is a shared responsibility of all humanity. Strengthening capacity building in emission accounting and policy designing in the energy sector can help developing countries to formulate mitigation strategies and implement mitigation actions.

GEIDCO is willing to work with all stakeholders to make unremitting efforts to achieve the Paris Agreement and Sustainable Development Goals!

