Support to the Government of Ukraine on updating its Nationally Determined Contribution

FINAL REPORT
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This Final Report combines all the analyses delivered by the team of technical experts within the EBRD project and throughout its duration, including the Inception Report, Background Report, Modelling and Scenarios Report and Policies and Measures Reports, which can be found on the official website of the Ministry of Environmental Protection and Natural Resources (https://mepr.gov.ua/news/33080.html) and are referenced in the updated NDC, submitted on 31 July 2021.

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BAU	Business as Usual (scenario)
BCA	Border Carbon Adjustment
BTR	Biennial Transparency Report (under the Paris Agreement)
BTU	British Thermal Unit
CAPEX	Capital Expenditures
CBAM	EU Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CGE	Computable General Equilibrium (model)
CHP	Cogeneration Plant
CMA	UNFCCC COP to the Paris Agreement
COP	UNFCCC Conference of the Parties
CSR	Corporate Social Responsibility
CTF	Clean Technology Fund
DFI	Development Finance Institutions
E5P	Eastern Europe Energy Efficiency and Environment Partnership
EAU	European Union Allowance
EBA	European Business Association
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EEF	Energy Efficiency Fund of Ukraine
EIB	European Investment Bank
ESCO	Energy Service Company
ESG	Environmental, Social and Governance
ESU	Energy Strategy of Ukraine by 2035
ETS	Emission Trading Scheme
EU	European Union
FC	Fuel Cell
FEC	Final Energy Consumption
GDP	Gross Domestic Product
GEF	Global Environment Facility Trust Fund
GFEC	Gross Final Energy Consumption
GHG	Greenhouse Gas
GVA	Gross Value Added
GoU	Government of Ukraine
HPP	Hydro Power Plant
IFI	International Financial Institution
IEA	International Energy Agency
IEF	Institute for Economics and Forecasting (Ukraine)
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LEDS	Low-Emission Development Strategy
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land Use Change and Forestry
MDB	Multilateral Development Bank

MPG	Modalities, Procedures and Guidelines (of the Paris Agreement)
MRV	Monitoring, Reporting and Verification
MSW	Municipal Solid Waste
MinEcology	Ministry of Environmental Protection and Natural Resources of Ukraine
NASU	National Academy of Sciences of Ukraine
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NEFCO	Nordic Environment Finance Corporation
NERP	National Emission Reduction Plan for Large Combustion Plants
NIS	National Inventory System
NPP	Nuclear Power Plant
NREAP	National Renewable Energy Action Plan
OECD	Organisation for Economic Co-operation and Development
PA	Paris Agreement
PMR	Partnership for Market Readiness (the World Bank project)
PPP	Purchasing Power Parity
RAB	Regulatory Asset Base (tariff)
RE	Renewable Energy
S1	Scenario 1/Business as Usual (BAU) Scenario
S2	Scenario 2/Reference Scenario
S3	Scenario 3/Climate-Neutral Economy Scenario
SIDA	Swedish International Development Cooperation Agency
SCC	Social Cost of Carbon (approach)
SDG	Sustainable Development Goal
SFRD	State Fund for Regional Development (operated by the Ministry for Communities and Territories Development of Ukraine)
TCFD	Task Force on Climate-Related Financial Disclosures
TIMES	The Integrated MARKAL-EFOM System (family of energy system models)
TPES	Total Primary Energy Supply
TPP	Thermal Power Plant
UCF	Ukrainian Climate Fund
UGEM	Dynamic Ukrainian General Equilibrium Model
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VAT	Value-Added Tax
VRE	Variable Renewable Energy (generation)
WEO	World Energy Outlook (by the IEA)

EXECUTIVE SUMMARY FOR POLICY MAKERS

General Project Information

This Final Report aims to summarize the final results of the comprehensive support, including all the technical reports produced within the project scope to inform different stages of the Ukrainian NDC development as well as describing the entire stakeholder engagement process, provided by the EBRD project "Support to the Government of Ukraine on updating its Nationally Determined Contribution (NDC)" implemented from November 2018 to September 2021 and funded by Sweden.

The EBRD project had the main objective of **supporting the Government of Ukraine in enhancing its climate ambition** by updating its first NDC (submitted by the GoU to the UNFCCC on 19 September 2016) by i) providing and informing the entire NDC development process – from preparation to consultation and submission – with necessary and appropriate technical information and analysis, produced by national and international experts and based on science and the best available information and data; ii) expanding the scope of the NDC beyond the energy system to an economy-wide analysis as well as covering both mitigation and adaptation; and iii) designing and supporting the consultation processes with a broad range of stakeholders.

During its lifetime, the project provided the Ministry of Environmental Protection and Natural Resources of Ukraine, as the key state authority in charge of compliance with the UNFCCC and Paris Agreement provisions, with support in updating the NDC, ensuring the following principles: i) the technical support is informed by the **best available information and science for achieving optimal emissions to meet the goal of net-zero emissions** in the second half of the century, taking into account the country context, including the feasibility and cost; ii) the technical analysis and its results, including the modelling, are based on science and real data, and the scenarios are developed using international best practices, especially regarding the definition of economy-wide decarbonization pathways; and iii) the stakeholder consultation and engagement process is transparent, inclusive and continuous.

Ukraine's updated NDC Development Process

This report aims to present **Ukraine's updated NDC development process** and is not the updated Ukrainian NDC itself as adopted by the GoU in July 2021. **The updated NDC of Ukraine is the outcome of an extensive stakeholder consultation and political discussion**. It is informed by the project's technical analysis and reports, but it is not entirely consistent with the Paris-aligned pathway proposed within this project. *It is important that the reader distinguishes between what was proposed as a result of the technical analysis presented here and what has been adopted by the GoU as its updated NDC. This highlights the nature of the NDC, which is ultimately a political decision that has legal standing and therefore requires the raising of political ambitions.*

For more information, see Section 1 of the Final Report.

Ukraine General Information

Ukraine is a sovereign, independent, democratic, social state with rule of law. It is one of the largest countries in Europe and is located in Central-Eastern Europe with a territory of 603,550 sq. km, covering 5.7% of Europe, with a population of **44.1 mln people** (2020).

Ukraine is a **low-middle-income country** with a current GDP of **155.6 bln US dollars** and a current (2020) nominal GDP per capita of **3,727 US dollars**. In 2020, the life expectancy at birth in Ukraine was **71.35 years**. According to the latest National Inventory, in 2019, the level of only CO2 emissions per capita was **5.0 metric tons**, and **7.5 tons** of CO2-eq. per capita (including LULUCF).

National Legislative Framework

The **EU–Ukraine Association Agreement** was ratified by the Parliament of Ukraine and the European Parliament simultaneously in September 2014 and entered into force in September 2017; it has become the core legislative document that defines Ukraine economy-wide policy ever since. The Association Agreement, in its scope and thematic coverage, is the biggest international legal document in the history of Ukraine and the biggest international agreement with a third country ever concluded by the EU. It serves as a strategic guideline for systematic socio-economic reforms in Ukraine and defines the format of relations between Ukraine and the EU on the basis of "political association and economic integration".

Ukraine is a party to the Paris Agreement, the UNFCCC and its Kyoto Protocol. Since achieving independence, Ukraine has made a significant contribution to the global GHG emission reduction. As of 2019, Ukraine had reduced its GHG emissions by 62.4% compared with its 1990 level including LULUCF and by 64% excluding LULUCF. Ukraine adopted and submitted its INDC on 16 September 2015 (later, in September 2016, this INDC became the first NDC). Ukraine defined its **first NDC target** as not to exceed 60% of the 1990 greenhouse gas emission level in 2030. In July 2021, Ukraine submitted its **updated NDC target** "that corresponds to an economy-wide absolute GHG **reduction of 65% by 2030, compared to the 1990 GHG emissions level**. By 2030, Ukraine plans to create a baseline for adaptation to climate change in order to increase resilience and reduce vulnerability to climate change, as foreseen in Article 7 of the Paris Agreement."

In March 2021, Ukraine developed and adopted its *National Economic Strategy till 2030*, which defines the achievement of a net-zero emission pathway by 2060, among many other sectoral goals. In September 2019, Ukraine adopted national *Sustainable Development Goals* in accordance with the UN Sustainable Development Agenda. In September 2017, Ukraine submitted its long-term *Low Carbon Development Strategy till 2050* under the Paris Agreement. *Ukraine's Energy Strategy* until 2035 is currently under revision. The country is working on various sectoral strategic policy documents that are aligned with, driven by or need to be aligned with the Paris Agreement and Ukraine's NDC, including but not limited to the National Ecology Security and Climate Change Adaptation Strategy till 2030, National Waste Strategy, National Transport Strategy till 2030, National Forestry Strategy till 2035 and Just Transition of Coal Regions Concept till 2030.

EU Green Deal alignment dialogue has been conducted since 2020 between the EU and Ukraine with a view to developing the so-called Ukrainian Green Deal. This dialogue has also included

the initial CBAM discussions between the EU and Ukraine and some elements of green recovery approaches, including green recovery finance.

The Ukrainian *MRV system* has been developed and has been undergoing implementation since early 2020 within the EU–Ukraine Association Agreement framework. As the next step, the development of the Ukrainian domestic *Emission Trading Scheme* (ETS) legislation will take place in late 2021.

Ukraine's NDC Updating Process

The project introduced a legislative and stakeholder engagement/consultation process for updating the NDC development and supported it throughout the whole process (see Section 1 of this report for more details). To fulfil the Paris Agreement goal on sustainable development, the project proposed the NDC and SDG alignment process discussed in Section 5 of this report.

The project also analysed the UNFCCC and Paris Agreement provisions and the requirements for the NDC transparency framework and proposed a step for implementing NDC transparency on the national level (see Section 6 of this report for more details). It conducted separate track work on adaptation that was not part of the first Ukrainian NDC, formulated a national adaptation goal and proposed sectoral adaptation policies and measures, which are presented in Section 3 of this report.

The core of the project's technical analysis work consisted of macroeconomic projections and pathway modelling of GHG emissions based on four designed scenarios (see Section 2 of this report and the separate Report 3 and Report 4 for more details). This cornerstone work was followed by climate finance analysis, which is outlined in Section 4 of this report.

The following key macroeconomic parameters were applied for further GHG emission pathway scenario modelling.

Long-term economic projection

Indicators	2021–2030	2031–2040	2041–2050
GDP growth rate in %, average for period	3.8	3.5	3.2
Mining and quarrying, growth rate in %, average for period	2.0	1.2	0.6
Manufacturing, growth rate in %, average for period	4.5	4.2	3.8
Industry, growth rate in %, average for period	3.5	3.2	2.9
Construction, growth rate in %, average for period	5.0	4.3	3.9
Services, share of GDP, average for period, %	52.7	54.3	55.7
Agriculture, share of GDP, average for period, %	9.3	8.2	7.3

Long-term demographic projection

Indicators	2018	2030	2040	2050
Population, mln	42.4*	39.7	37.7	35.6
Average life expectancy, both genders, years	72.2	73.9	75.3	76.7
Average population age, both genders, years	40.5	42.7	44.4	45.4
Share of working-age population, both genders, %	51.1	48.4	47.5	43.0
Number of retired per working persons, both genders, persons	0.99	1.14	1.24	1.49
Share of rural population, %	32.6	31.6	30.2	28.6

** The population is aligned with data reported by the State Statistics Service of Ukraine and does not include the annexed territory of the Republic of Crimea. For the purpose of the NDC, these numbers have been correspondingly adjusted.*

World energy price projection

Energy Source	2017	2020	2025	2030	2035	2040	2045	2050
Coal, EU, USD 2017/t	85	90	80	83	84	85	87	89
Brent oil, USD 2017/barrel	52	65	88	96	105	112	121	132
Natural gas, EU, USD 2017/mln BTU	5.8	6.0	7.8	8.2	8.6	9.0	9.4	9.9

It is important to mention that the project was building long-term emission pathways extending beyond the NDC 2030 time frame to assist the GoU in building long-term pathways and to ensure continuity of its climate ambition actions in the long term while achieving the NDC target in 2030. At the same time, the project aimed to conduct technical analysis of a possible Paris-aligned pathway for Ukraine in the long term, to set appropriate interim targets to achieve such a transition and to identify the policies and measures that would be needed and their costs.

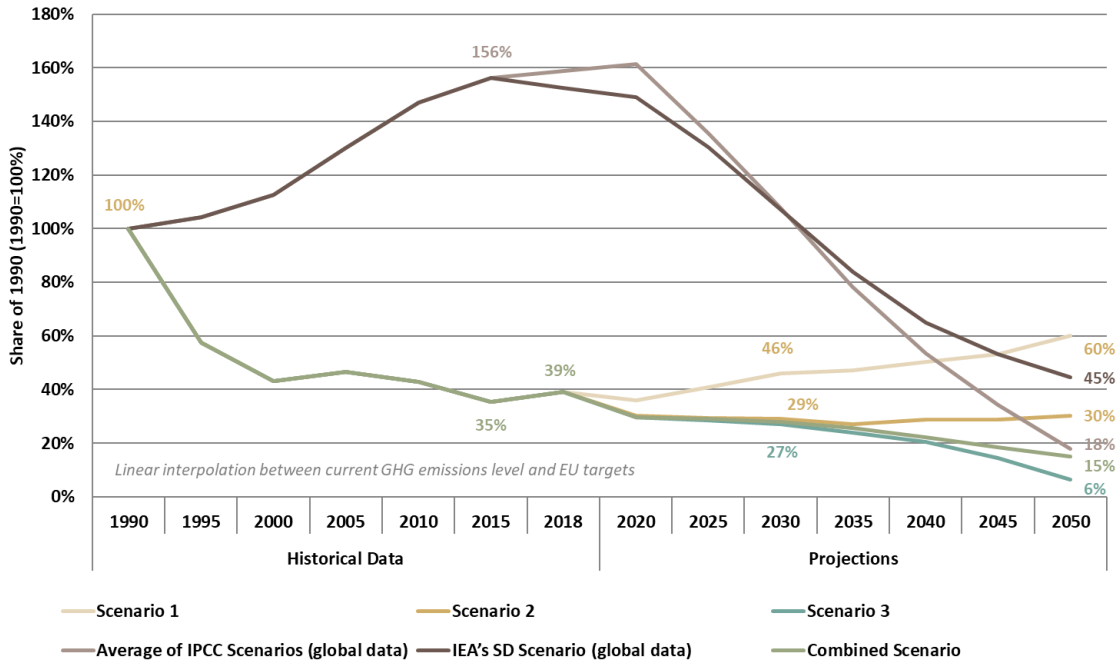
Modelling

As a result of consultations and coordination with the GoU, a set of internationally recognized modelling tools was selected for Ukraine's NDC scenario modelling framework approach (see Figure 2.1 of this report). The **TIMES-Ukraine model** was used for GHG emission pathway modelling in the energy sector, together with the dynamic Ukrainian **general equilibrium model** and modelling tools based on the IPCC approach – **mass balance model** for the Waste sector and EXCEL-based application for the LULUCF sector. A combination of the optimization least-cost energy system, macroeconomic (CGE) and sectoral models is the most common method of determining long-term, cost-optimal energy/emission pathways based on a range of different assumptions. The modelling process is described in detail in Section 1.4 of this report and in the separate Report 3 and Report 4.

The following four NDC/GHG emission pathway scenarios were designed and further modelled:

- Scenario 1, or the "**Business as usual (BAU) scenario**", was set as an "exploratory scenario", assuming that no fundamental changes take place and particularly that no additional emission reduction measures are implemented during the projected period;
- Scenario 2, or the "**Reference scenario**", contains numerous targets and indicators to be achieved according to the current legislation modelled as policy constraints with a policy-specific timeline (e.g. the Energy Strategy until 2035 indicators and targets and the NEEAP, NREAP and LEDS indicators);
- Scenario 3, or the "**Climate-neutral economy scenario**", contains the same set of policy targets as applied to the reference scenario with an additional target constraint imposed on the level of GHG emissions per capita by 2070;
- Scenario 4, or the "**Combined sensitivity scenario**", was modelled on the baseline economic development scenario and included the conditions of Scenario 2 for the sectors of agriculture and land use, land use change and forestry (LULUCF) as well as various sensitivity options, including carbon tax and nuclear power station variables and others (see Section 2.3 for further details).

The results of the extensive modelling exercise, conducted in continuous coordination with the GoU, are presented below and in Sections 2.4–2.6 in this report.



Ukraine's GHG Emission Pathways

Climate Finance and Investments

Once the designed scenario modelling process had been finalized and taken through an extensive, over 12-month-long, broad stakeholder consultation process in various formats with over 1200 participants (see Section 1 of this report) for discussion, inputs and numerous iterations, the estimation of the investment needed for the implementation of each of the four NDC scenarios was conducted.

GHG emissions and investment needs by updated NDC scenario

Scenario Name	GHG emission reduction compared with the 1990 level		Investment needs (without consumer spending), billion euros		Renewable energy share			
					Electricity production		TPES	
	2030	2050	2020–2030	2020–2050	2030	2050	2030	2050
Business as usual	-54%	-40%	202	671	17%	24%	5%	8%
Reference	-71%	-70%	241	731	30%	45%	13%	20%
Climate-neutral economy	-73%	-94%	256	971	34%	56%	15%	38%
Combined sensitivity	-72%	-85%	263	798	31%	86%	15%	53%

The results of the broad stakeholder consultation process had identified the **combined sensitivity scenario (Scenario 4)** as the most ambitious and as still being realistic for Ukraine. To assess the financial feasibility of this scenario, the project conducted an analysis of additional potential sources of climate finance, proposed potential climate finance governance, identified institutional gaps and challenges and proposed scenario-specific steps that will need to be taken by both government authorities and private finance institutions and entities to attract and leverage the required climate finance investment for the combined sensitivity scenario. The

modelling results for Scenario 4 indicate that its implementation requires the attraction of on average around 26 bln euros annually up to 2030. As this is estimated to represent 70–80% of all capital investments, the average capital investment over the 2021–2030 period is expected to be **at least 33 bln euros annually**. Given that the capital investments in Ukraine totalled around 20 bln euros in 2019, this represents a 65% increase against the 2019 data for the average investment year. As such, the total capital investments required to enable the Ukrainian economy to transition to a low-carbon development pathway are reasonable in absolute terms, considering the historical trends. Across all sectors, **own enterprise funds and bank loans** are expected to **deliver nearly 90% of the total financial resources**. The role of state and local budgets, albeit fluctuating per sector, is estimated to be responsible for just under 7% of the total CAPEX, which is in line with the historical share that domestic public finance has provided in capital investments in Ukraine.

Ukraine should anticipate that a growing share of future EU funding is likely to be earmarked for the development and implementation of Ukraine's low-carbon development roadmap, which may support the incremental costs associated with a more ambitious NDC target. We project that one-third of future EU finance for Ukraine will be earmarked for such climate-related investments in the 2021–2030 period, amounting to least 10 billion euros – or nearly one-fifth of the total incremental funding required – that could be leveraged in support of the identified incremental investments (equivalent to 1 bln euros per year).[1] Currently, the **EU-based DFI flows** have averaged **at least 1.7 bln euros per year**, with EU budget funding averaging an additional 1.3 bln euros per year.

Carbon-Pricing Approaches/Instruments

In the combined sensitivity scenario, the foreseen implication of a higher carbon tax would be to raise public funding for low-carbon investments. When the price of the tax is increased to 5 euros per tonne, the total carbon revenues raised through the carbon tax would amount to 9.3 bln euros, or just under 1 bln euros per year. Doubling this price to **10 euros per tonne** would generate cumulative revenues of 18.5 billion euros, equivalent to **nearly 2 bln euros per year**. Over a 10-year period, this would translate into total potential revenue of 20 bln euros (difference between BAU and combined scenario), representing one-third of the total incremental funding required for NDC implementation.

While such carbon price may appear high compared with the current price level, it should be noted that prices under the EU-ETS reached a record high of 80 euros at the end of 2021, and the EU is likely to use the EAU price as a benchmark for pricing the border adjustment tax proposed under the EU Carbon Border Adjustment Mechanism. Increasing taxation domestically (rather than paying the tax at the EU border for exported products) and redirecting these increased revenue streams into a national climate fund could cover as much as one-third of the incremental CAPEX costs estimated over the 2021–2030 period. A more detailed approach to climate finance and concrete steps for Ukraine are outlined in Section 4 of this report.

[1] Across all DFIs, climate finance contributions predominantly support energy generation, efficiency and supply projects, followed by transport and infrastructure projects. The total flows to Ukraine, despite decreasing in the 2015 to 2018 period (from 940 mln US dollars to 519 mln US dollars), almost doubled in the subsequent year, reaching 1,115 mln US dollars in 2019. Since the leading DFIs collectively committed to channelling at least 65 bln US dollars into climate finance annually by 2025 (a figure that is 50% above the 2019 levels), it is reasonable to expect that Ukraine will continue to be able to benefit from these international climate finance channels throughout the 2021–2030 period.

Policies and Measures

To implement the NDC target, the project developed a comprehensive cross-sectoral list of policies and measures that need to be either implemented or developed and then implemented. Proposed in Report 4 and outlined in Section 3 of this report, the policies and measures are economy wide, including the electricity, heating, transport, industry, housing and waste sectors as well as agriculture and forestry, bioenergy, the fiscal market, society covenants and adaptation with over 150 sector-specific, cross-sectoral, financial and behaviour pattern policies and measures that are aligned with the existing national legislation or international obligations of Ukraine and will put Ukraine on a track towards a sustainable and climate-resilient economy and society while ensuring green recovery and pursuing the pathway to the sustainable transition to a net-zero and equally fair society (alignment of the Paris Agreement and EU Green Deal).

The proposed policies and measures will serve as a basis for developing the so-called NDC National Action Plan, which is required by the legislation framework for any policy document to be implemented. The work on the NDC Implementation Action Plan was launched in early September 2021 by the GoU.

NDC Implementation and Next-Step Recommendations

High-level key messages on the updated NDC process and the Paris Agreement provision alignment for policy makers based on the project's technical analysis findings

The project has been conducting sectoral and cross-sectoral technical analysis and developing policy approaches for almost 3 years within the scope of developing the Ukrainian NDC, and, even though the national political process resulted in the adoption of a different, but still technically aligned, updated Ukrainian NDC target, the project considered that the GoU could use the project findings for further long-term strategic national and sectoral sustainable development planning processes, such as informing the national process on the Ukraine Green Deal and Green Recovery Plan discussions, updating the Energy Strategy, finalizing the Integrated Energy and Climate Action Plan and others. These key messages could inform the further development of the sustainable national legislative framework and green transformation pathways.

- The modelling results show that it is possible for Ukraine to move towards a long-term path that will deliver a sustainable low-carbon and climate-resilient Ukrainian economy with deep emission cuts consistent with the goals of the Paris Agreement.
- Focusing in the near term on the full implementation of the existing and planned short-term policies and measures is critical. Our analysis has shown that this will not significantly alter the current economic composition and will allow the possibility for Ukraine to enhance its ambition and achieve net-zero emissions by 2070, while the recently adopted National 2030 Economic Strategy set the target to achieve net-zero emissions even earlier, by 2060.
- Such an enhanced ambition for the long term will open up the potential for the country not only to transform the economy into a carbon-neutral economy but also to foster innovation and competitiveness and provide a clean service- and technology-driven economy, avoiding capital lock-in into inefficient and stranded assets.

- Ukraine already has the foundation to deliver progress between now and 2030. However, the policies and measures necessary to allow the economy to shift onto carbon neutral development pathway. Long-term climate policies need to be set with respective targets, the changes are required in the following areas:
  - A further increase in renewable energy installed capacity;
  - Early adoption of the new technologies, e.g. hydrogen and CCSU;
  - Significantly more energy-efficient buildings;
  - Increased electrification of transport;
  - Better waste management and water use;
  - Increased organic crop production and a reduction of methane in agriculture;
  - Increased carbon sink through afforestation.

Recommendations on the NDC implementation for the GoU, including institutional recommendations, the elaboration of policies and the development and implementation of measures within the National NDC Action Plan process and the financial concept of NDC implementation and its approaches.

Adopted in July 2021, the national updated NDC target was an important milestone in the implementation of Ukraine's Paris Agreement provisions on the pathway to sustainable development and green transformation of the Ukrainian economy and society. While the development and adoption of the updated NDC took almost 3 years of extensive technical work, coordination and a stakeholder consultation process, it is expected that the GoU will be able to build on the results of this work to develop its NDC implementation plan in line with the relevant legislation provision and in an expedited manner. This process of National NDC Implementation Action Plan development was launched by the GoU in September 2021 and is ongoing.

The Action Plan aims to elaborate on specific policies, measures and steps, identify responsible state authorities and specify timelines, a budget and its source for each policy and measure. This work is a crucial milestone in implementing the updated NDC as only an action plan that is adopted domestically will operationalize the NDC and the GoU to implement the adopted and communicated NDC. Building on the development and implementation of previous strategic documents, the development and adoption of a proper NDC Implementation Action Plan is expected to take from 6 to 12 months, preliminary by February 2022.

The following recommendations could inform the development of comprehensive cross-cutting national legislation, including a National NDC Action Plan with either a 5-year or a 10-year cycle, a toolkit of sectoral concepts and action plans setting Ukraine on the pathway to implementing the NDC and achieving its target with a view to revisiting the current updated NDC by 2025. The updated NDC implementation process would require new and innovative approaches at the **institutional level** due to its cross-sectoral and transformational nature, including financial transformation. At the same time, it would need to be aligned with the existing legislation implementation processes, including but not limited to the Energy Strategy, Waste Management Strategy, National 2030 Economic Strategy and potentially emerging new legislation. Therefore, setting up a special ad hoc task force under the *governmental committees on economic and financial policies, fuel–energy complex, community development and environment protection* is recommended.

This institution-level step would allow the development of **comprehensive cross-sectoral NDC implementation legislation** and expedite the coordination and consultation processes. The overarching mandate of this governmental committee would also enable the establishment of a relevant platform for Ukrainian climate finance and the green taxonomy legislation framework.

The proposed institution-level step would also create a proper space for the elaboration and prioritization of **NDC policies and measures** on the sectoral and cross-sectoral levels while ensuring the cross-cutting nature of most of the policies, aligning them with the existing legislation framework and avoiding overlaps. These policies and measures could serve as a basis for the **Integrated Energy and Climate Action Plan** required by the Energy Community. The cross-sectoral nature of the governmental committee would also enable close coordination with the **Just Transition** of Coal Regions initiative and any other energy and climate initiatives and programmes while ensuring that the implementation of NDC policies and measures puts Ukraine on the pathway to a green post-COVID recovery and the pursuit of national sustainable development goals.

The proposed policies and measures under the updated NDC development process cover all the sectors of the economy and society transformation, including adaptation policies and measures and relevant financial sector policies to introduce the green taxonomy concept and to establish a climate finance framework with the aim of implementing all the proposed policies and measures in sustainable and timely manner. Therefore, the proposed policies and measures could frame the relevant sectoral concepts and approaches, while the existing sectoral policies should be cross-checked against the updated NDC target contributions and revised if required.

The implementation of the **adaptation policies and measures** proposed to achieve the adaptation goal of establishing a national adaptation legislation framework will require a separate track of consultations and adoption, most likely within the existing National Adaptation Strategy development process.

The **financial concept** for NDC implementation could be built on the climate finance analysis conducted within the project's scope with a view to operationalizing its key recommendations on the national and regional levels and enabling public finance to leverage the required private finance that will contribute to achieving the updated NDC target and long-term goal of net-zero emissions by 2060 as defined in the National 2030 Economic Strategy.

Recommendations for enhancing the NDC transparency cycle, including regular processes of national NDC updating by establishing a holistic and comprehensive national NDC transparency system as per the relevant Paris Agreement provisions

The updated NDC is the second NDC developed by the GoU under the Paris Agreement provisions since 2015. A 5-year cycle of NDC submissions will be defined further for the post-2030 time frame later, but it is clear now that regular updating or revision of the NDC will be required by Ukraine. The lessons learned during this project show the necessity of establishing a continuous and enhanced NDC transparency framework on the government level, which will be based on the existing National GHG Inventory System, while using the best international practices for modelling, monitoring and verification and lessons learned on the national and regional levels. Such an NDC transparency framework will enable the provision of continuous, reliable and comparable data to inform the NDC development and reporting processes, which will become increasingly complex after each NDC submission cycle, will include more and more elements and will reach a deeper level of granularity in each reporting and submission cycle in

accordance with the relevant Paris Agreement provisions for an enhanced transparency framework and regularly revised IPCC Guidelines.

As the NDC implementation period started in January 2021, there will be new elements for reporting within the transparency framework and its reporting cycles (see Section 6 on transparency for more details); therefore, the establishment of enhanced continuous monitoring systems for climate finance, technology transfer and capacity building and response measures for climate adaptation and resilience is recommended.

While implementing the Paris Agreement provisions, Ukraine will also pursue the implementation of other national, bilateral and multilateral agreements, for example the EU–Ukraine Association Agreement, Energy Community and others, so the alignment of the NDC transparency framework with the recently established MRV system and the emerging domestic ETS is also a very important step in the transparency framework.

Other potentially emerging initiatives, such as the Ukraine Green Deal, Green Recovery Program, Green Taxonomy and others, should also be aligned with the NDC and cross-checked against the contribution to sustainable green growth and the achievement of net-zero emissions, including its proper reflection in the NDC transparency framework.

SECTION 1. BACKGROUND INFORMATION

Ukraine's Revised NDC (the "updated NDC", following the first submitted in 2016) under the Paris Agreement

In accordance with paragraph 9, Article 4 of the Paris Agreement, Ukraine shall submit its NDC every 5 years. The first Ukrainian INDC was developed by the GoU, adopted by Cabinet of Ministers Decree No. 980-p on 16 September 2015 and submitted to the UNFCCC Secretariat in September 2015. On the official NDC registry website, the date of the first Ukrainian NDC submission is indicated as 19 September 2016 as this is the factual date of the finalization of the Paris Agreement ratification process by Ukraine – the date when Ukraine deposited its instruments of acceptance with the UN Secretary-General, the Depository of Agreement, Ukrainian Parliament, and ratified the Paris Agreement on 14 July 2016 by adopting the Law on Ratification of Paris Agreement No. 1469-VIII.

The Ministry of Environmental Protection and Natural Resources of Ukraine is the official UNFCCC Focal Point and, in accordance with its mandate, is in charge of the implementation of the UNFCCC, Kyoto Protocol and Paris Agreement provisions. The development and submission of the national NDC is part of the Ukrainian commitments under the Paris Agreement; therefore, MinEcology is in charge of developing the national NDC for Ukraine.

In accordance with paragraph 24 of decision 1/CP.21, Ukraine could choose between updating its first NDC and submitting its second NDC. MinEcology decided that Ukraine would develop and submit its **revised/updated (official title of the 31 July 2021 submission) NDC** and will comply with the COP24 Katowice decision on *Further Guidance in Relation to the Mitigation Section of Decision 1/CP.21*, including the provisions of Annex I, as applicable. Once the Ukrainian updated NDC has been submitted, the national reporting on NDC implementation under the Paris Agreement will comply with the relevant COP24 Katowice decisions, including, but not limited to, the transparency decision and Annex II of the decision on *Further Guidance in Relation to the Mitigation Section of Decision 1/CP.21* (see Section 6 of this report).

During the first Working Group meeting, the project proposed and the Working Group members agreed the structure of the Ukrainian updated/second NDC in accordance with the relevant provisions of Annex I of Katowice decision 4/CMA.1: *Further Guidance in Relation to the Mitigation Section of Decision 1/CP.21*.

Ukraine's NDC National Legislative Process

The project outlined the legislative process for the development of the NDC for Ukraine based on the national legislative framework, best international practices and lessons learned during previous NDC processes. Each of the proposed legislative steps was supported by the project during its lifetime. All the NDC legislative steps were developed, taking into account the relevant COP and CMA decisions and the Paris Agreement provisions.

The national legislation process for updating Ukraine's national NDC:

- Establishment of the Inter-ministerial Working Group for the updating of NDC under MinEcology with broad stakeholder participation;
- Regular meetings of the Working Group to discuss specific NDC elements and present intermediate results;

- Methodological workshop to present the available methodological approaches to NDC development and to select the most appropriate methodology or combination of methodologies for Ukraine;
- National and international experts' contribution and consultations;
- Sector-specific inter-agency consultations;
- Private and public business consultations when achieving specific benchmarks;
- Finalization of the updating NDC process and drafting of the Ukrainian updated NDC in the format of a GoU Decree;
- Formal public consultations on the draft Ukrainian updated NDC;
- Ministerial and state agencies' formal concurrence process based on the Cabinet of Ministers' legislation development process regulation;
- Concurrent councils/consultations with ministries and state agencies to address specific unresolved issues/comments if necessary;
- Development of supporting documents in accordance with the Cabinet of Ministers' legislation development process regulation and preparation of the draft updated NDC in line with the received comments if applicable;
- Submission of the updated NDC and supporting documents to the Cabinet of Ministers of Ukraine for adoption;
- Supporting Cabinet of Ministers Secretariat on the updated NDC consultations and discussions;
- Adoption of the Ukrainian updated NDC by the relevant GoU Decree;
- Submission of the English version of the Ukrainian updated NDC to the UNFCCC Secretariat.

Project Inception Stage

The EBRD received a request from the Ministry of Energy and Environmental protection to support the Government of Ukraine in updating its NDC in view of its 2020 submission to the UNFCCC ahead of COP26. The project was officially launched at an inception meeting hosted by the Ministry of Energy and Environmental protection in Kyiv, attended by representatives from all the key ministries, on 21 November 2018.

With the government restructuring that took place in 2019 and the separation of the Ministry of Environmental and Protection and Natural Resources from the Ministry of Energy as a separate government body, the official focal point for the assignment became the Ministry of Environmental Protection and Natural Resources, which is responsible for Ukraine's NDC preparation and for coordinating the Inter-ministerial Working Group and consultation processes for the NDC.

This technical assistance that the EBRD provided for Ukraine, funded by the SIDA, had the main objective of supporting the Government of Ukraine in enhancing its climate ambition by updating its first NDC (the result of which hereafter will also be referred to as "updated NDC" to differentiate it from the first NDC of Ukraine, submitted on 16 September 2019 to the UNFCCC registry) by i) providing and informing the entire NDC process – from preparation to consultation and submission – with the necessary and appropriate technical information and analysis,

produced by experts and based on science and the best available information and data; ii) expanding the scope of the NDC beyond the energy system to an economy-wide analysis as well as covering both mitigation and adaptation; and iii) designing and supporting the consultation processes with a broad range of stakeholders.

Stakeholder Consultation Process

Ukraine's NDC updating process was built on the principles of a transparent and inclusive ongoing stakeholder consultation process, which was launched in November 2018 at the initial Working Group meeting under the Ministry of Ecology and Natural Resources of Ukraine; subsequently, the formal Working Group on the NDC updating was established under the Ministry of Ecology and Natural Resources (now the Ministry of Environmental Protection and Natural Resources of Ukraine).

The Inter-ministerial Working Group on the updated Ukrainian NDC development consisted of representatives of all the interested ministries and state agencies, legislators, local authorities, industry associations and private businesses, civil society and academia, with over 75 members. During the process of NDC development, over 1200 participants were involved in various types of stakeholders' consultations, meetings, high-level discussions, round tables, talks and online meetings for a period of almost 3 years. This transparent and inclusive consultation process ensured the understanding, involvement and buy-in of all the interested stakeholders at each step of Ukraine's updated NDC development process.

The major milestones of Ukraine's updated NDC stakeholder consultation process were:

- First meeting of the updated NDC Working Group – 4 February 2019
- Conference on Modelling Instruments for updated NDC – 26 February 2019
- Working Group on updated NDC development formally established by MinEcology decree
- Methodological seminar on updated NDC – 13 March 2019
- Second Working Group meeting on updated NDC development – 17 August 2019
- Third meeting of the updated NDC Working Group – 14 February 2020
- Fourth meeting of the updated NDC Working Group (online) – 26 November 2020
- Updated NDC Policies and Measures for Stakeholders' Consultation during the December 2020–May 2021 period (including over 20 sectoral consultation meetings with relevant ministries, state entities, business associations and others)

SECTION 2. UKRAINE'S UPDATED NDC MODELLING APPROACH AND RESULTS

2.1 MODELLING FRAMEWORK

As the global combustion of fossil fuels has been the main source of GHG emissions, integrated energy system models have also been used traditionally for the projection of prospective GHG emissions and the analysis of mitigation policy options. Such technology-based modelling with explicit representation of energy commodities and energy technologies makes thorough tracking of various types of emissions and pollution from fuel use possible and thus is much more reliable for this purpose than the use of macroeconomic models, in which energy carriers are presented as dummy "sectoral products" in monetary terms, while technology-specific parameters, such as lifetime or investments, are hardly considered. In the meantime, being concentrated on the energy sector (even being of the partial equilibrium type), traditional energy system models are limited to providing solid economic and social assessment of the resulting energy and technology mix. Conversely, the unification of technology specifications, required to describe the whole energy system, makes them still less comprehensive than specific sectoral models, such as power system or transport sector models.

For this reason, the **combination of energy system, macroeconomic and sectoral models is the most common approach to determining long-term, cost-optimal energy/emission pathways based on a range of different assumptions**, such as GDP growth rates, cost-effective energy saving and renewable energy potential, foreign trade flows, the development of various generation types, energy production, transformation and consumption technologies, including carbon capture and storage, and so on.

The modelling framework adopted for assessing the new target and respective pathways for Ukraine's updated NDC employed several mathematical models, including:

- The energy system TIMES-Ukraine model, which covers the energy and industrial process sectors;
- The waste sector mass balance model and an Excel-based tool for the agriculture and LULUCF sectors, which, together with the TIMES-Ukraine model, covers 100% of GHG emissions in Ukraine;
- The dynamic Ukrainian general equilibrium model (UGEM), which was used to estimate the social and economic impacts of the energy decarbonization policies and measures;
- The visualization and analysis tool[2] used to ensure comprehensive visualization of the current national GHG inventory data of Ukraine and the existing data at the sectoral and sub-sectoral levels with trend analysis and a comparison with other parties.

The TIMES-Ukraine model, as the core of this modelling framework, is a technology-rich model and provides information across sectors on the types of energy used by year, technology uptake, GHG emissions and costs across the energy system. It is a tried and tested analysis tool and, together with the UGEM, has already been used in a number of national and international studies as well as in the preparation of governmental documents such as the Low Emission Development Strategy under the Paris Agreement (2017), the Draft of the Seventh National Communication on Climate Change (2018), the National Energy Efficiency Action Plan till 2020

[2] See https://ukraine.ndc.quest/index.html for detailed updated NDC modeling results.

(2015), the draft Second NEEAP for the period 2019–2030 (2019) and scenarios for the Action Plan of the Energy Strategy of Ukraine by 2035 (2019). For more details of the TIMES modelling approach, see https://iea-etsap.org .

Waste sector modelling is based on national tools applying the mass balance model reflecting country-specific waste statistics structure, which was used in line with National Waste Management Strategy till 2030 definitions and targets' list. The forestry and agriculture sectors' modelling of emissions relied on the combined IPCC and national bottom-up approach. All fuel combustion in the waste and forestry sectors was modelled using the TIMES-Ukraine forecasting process. The modelling framework presented in Fig. 2.1 below is described in more detail **in Annex 1**.

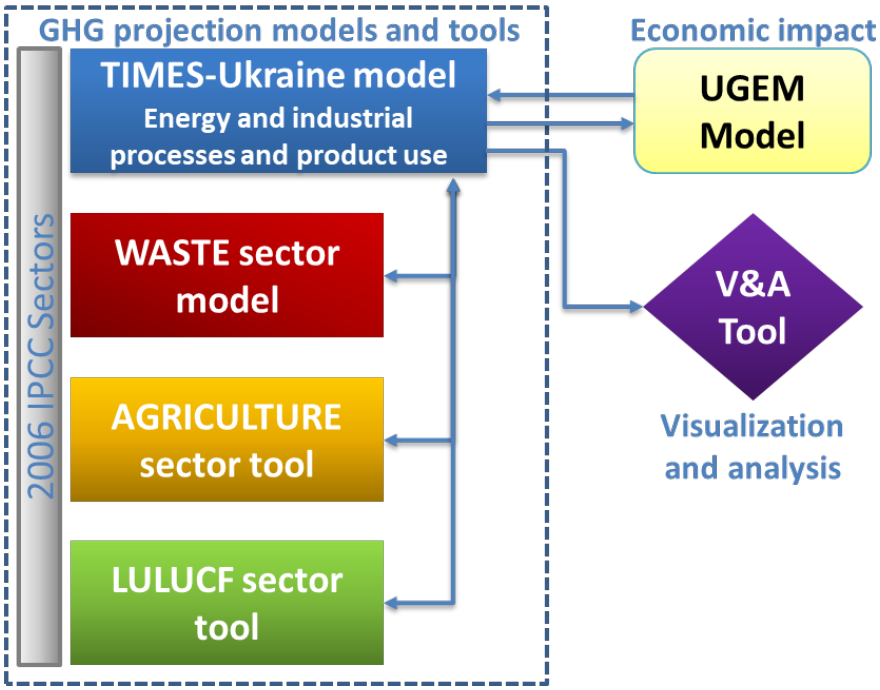


Figure 2.1. Modelling framework for Ukraine's updated NDC

The modelling framework was considered and accepted by the Ministry of Environmental Protection and Natural Resources of Ukraine (at that time called the Ministry of Energy and Environmental Protection of Ukraine) and endorsed during the Inter-ministerial Working Group on updated NDC Development in June 2019.

2.2 MODELLING PROCESS

General Approach

Prior to the assessment of energy and GHG emission policies and targets, a set of assumptions was prepared, including:

- **Exogenous assumptions**: not directly related to the subject of research and setting the common framework of modelling – such as economic and demographic assumptions, international energy prices, fossil fuel reserves or renewable energy potential and technical parameters of energy technologies;
- **Endogenous assumptions**: composing policy scenarios to study via modelling – in our case, technological and policy options for energy and the environment.

This study follows **the principle of "perfect foreseen modelling"**, meaning that the demands (energy and transportation services and feeding demands) are explicitly defined by exogenous assumptions and could be met by processes (technologies) with a different set of input energy commodities and therefore different levels of emissions. The set of such processes is estimated via modelling, considering endogenous assumptions by scenario. For example, the space heating demand in the TIMES model is assessed as the floor area (but not energy units) using the number and category of residential dwellings in urban and rural areas, taking into account the dynamics of the population in the place of residence and the composition of households, the growth rate of the specific dwelling area per resident and the construction of new buildings with centralized and individual heating systems. The economically optimal solution for the fuel and technology mix is then obtained by the model based on the analysis of alternative technological options of heat production, supply and consumption or energy-saving measures with respect to the imposed energy/environmental policy constraints. ***Non-technological measures*** that can affect the predefined demands, such as triggered changes in social attitudes and shifts in transport mode, diet or workstyle, ***were not considered*** in this report. Besides, mathematical models used in this study do not take into account possible impact of physical climate risks in the economy depending on the future temperature changes and correspondent increase in required investments for adaptation, thus being focused solely on mitigation measures.

While exogenous assumptions are common to all the scenarios, *endogenous assumptions are scenario specific* as they are imposed to reflect the specific policy option to be modelled and assessed, such as the energy or GHG targets, the market penetration of new technologies or the introduction of a carbon tax. Such a sequence of assumptions and scenarios is important to guarantee the adequate comparability of modelling calculations. For example, if the achievement of the target (endogenous assumption) is assessed, both calculations (with and without target constraints) need to be based on the same economic and technological assumptions (exogenous assumptions).

For this reason, the GHG emission pathway scenarios (updated NDC scenarios) presented in this report **differ from each other regarding the energy/environmental policy assumptions**, such as the prospective EE or GHG targets. Meanwhile, to make the scenarios mutually comparable, **other scenarios' assumptions that predetermine the development of the energy system**, such as macroeconomic (GDP, value added and production by sector, energy prices), demographic (the quantity and income of the population and the housing stock) and technological (the costs of technologies and the available RE&EE potential) assumptions, **were kept uniform for all three scenarios**.

The GDP development by sector and other economic assumptions **are based on the integrated economic projection, that is, a short-term projection until 2022, prepared by the Ukrainian Government in May 2019,**[3] **which was then extended by IEF experts to 2050**. The macroeconomic projection is **supplemented by**:

- **The demographic forecast** by the Institute of Demography and Social Studies, NASU;
- **The global energy price projection** from the IEA World Energy Outlook 2018;
- Energy sector-specific assumptions, such as the EE&RE potential by sector, as these parameters are also exogenous for this report.

[3] Projection of the economic and social development of Ukraine for 2020–2022, adopted by the Cabinet of Ministers of Ukraine on 15 May 2019 (No. 555). https://zakon.rada.gov.ua/laws/show/555-2019-%D0%BF.

Baseline Projection

The development of a baseline projection is a crucial step in understanding the GHG emission reduction potential in the current year and up to 2050. For example, it is not possible to identify mitigation measures in the energy sector without knowledge of the "normal" prospective energy demand trajectory across different sectors. Energy supply/demand baseline calculations provide information on fuel use, types of technologies used and policies and measures in place under "normal" development.

- Scenario 1, or the "**Business as usual (BAU) scenario**", is set as an "exploratory scenario", assuming that no fundamental changes take place and particularly no additional emission reduction measures are implemented during the projected period. The main purpose of the BAU scenario is to create a basis for comparison with other scenarios.

Policy Scenarios

The next step is to formulate and run policy scenarios to assess the contribution from various mitigation measures to GHG emission reduction:

- Scenario 2, or the "**Reference scenario**", contains numerous targets and indicators to be achieved according to the existing and drafted legislation modelled as policy constraints with a policy-specific timeline (e.g. the Energy Strategy indicators and targets, which ought to be achieved by 2035, and the NEEAP, NREAP and LEDS indicators).
- Scenario 3, or the "**Climate-neutral economy scenario**", contains the same set of policy targets as the reference scenario *with an additional target constraint* imposed on the level of GHG emissions per capita in 2050, assuming that the country is on track to reach emission neutrality by 2070.

Assessment of GHG Emissions

The BAU and reference scenarios by design involve models to estimate the GHG emissions until 2050. In the case of the **BAU** scenario, it is a result of the limited implementation of existing and drafted legislation and policies, whereas the **reference scenario** is the outcome of the full implementation of the relevant existing and drafted legislation and policy implementation, carried out in the most economically viable way, which results in the GHG emission estimation but not as an in-built cap.

On the other hand, the **climate-neutral economy scenario** sets a clear cap on the GHG emissions per capita level, with a maximum of 1.7 t CO_2-eq./year in 2050 (in line with the IPCC Special Report on Global Warming of 1.5 ºC[4]), and the modelling is undertaken based on this default value. Based on Article 4 of the Paris Agreement,[5] Scenario 3 assumes that a net-zero carbon-neutral economy can be achieved in Ukraine by 2070.

[4] https://www.ipcc.ch/sr15/

[5] According to Article 4 of the Paris Agreement, "… Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."

Consideration of Costs and Investments

The calculation of the energy system development and the corresponding GHG emissions in each scenario was performed under minimization criteria of the **total energy system costs**,[6] which include:

- capital investments (costs) both for the construction of new energy assets and for the purchase of final energy consumption appliances, some of which could be considered not as investment but as intermediate production or final consumer costs;
- fixed and variable operating and maintenance costs for energy production, transportation and consumption technologies;
- energy and fuel costs (expenditures) assessed on the basis of the marginal cost of each type of fuel, taking into account the cost of imported resources;
- concessions, rental or other payments (target allowances, emission tax, etc.).

This methodological approach allows the development of energy/environmental projections from the standpoint of the *minimization of social costs and at the same time the utility maximization of energy producers and consumers*. Thus, the capital investments considered in the TIMES model are not just investments in the energy sector but more precisely *"energy-related investments", accounting for about 60–70% of the total investments in the economy*.

Impact Assessment

The additional economic effects and benefits resulting from the implementation of energy or environmental policies (such as those improving the foreign trade balance or generating a demand for manufacturing, affecting economic performance or employment in industry, services, construction, etc.) **are not considered in the TIMES-Ukraine and sectoral models**. However, experience shows that the true impact of such policies should be sought across the whole economy. Therefore, the **assessment of the cross-sectoral effects of the implementation of policy scenarios was carried out using the UGEM**, and disaggregated results from the sectoral models were used as an input data for this analysis. The approach of mapping the TIMES-Ukraine model and the UGEM is broadly described in Annex 1.

Sensitivity Analysis

The sensitivity analysis aimed **to test the robustness of the original scenarios in the case that different key macroeconomic and technological assumptions are applied**. To conduct the sensitivity analysis, the most critical factors/variables that may affect the future GHG emission pathways were identified. By altering these variables within a range, the results indicated the extent to which such changes would affect the overall GHG emissions or corresponding system costs. The results of rerunning the model with altered variables showed whether certain additional policy or technological options are critical and thus require more thorough policy analysis and recommendations. The sensitivity analysis

[6] This methodological approach is generally accepted; for example, see Impact Assessment. Energy Roadmap 2050 (https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1565_part1.pdf) or Impact Assessment of the Energy Efficiency Directive (2012/27/EU) for the Energy Community (https://www.energy-community.org/portal/page/portal/ENC_HOME/DOCS/3304025/Report_for_web.pdf).

resulted in the composition of the **combined sensitivity scenario**, which included sensitivity options with a notable positive effect on emissions and required investments.

2.3 INPUT DATA AND ASSUMPTIONS

Baseline Macroeconomic Projection

The Baseline Macroeconomic Projection was developed based on the short-term governmental projection to 2022[7] and its further extension to 2050 conducted by the IEF experts. It was assumed that **the annual growth of GDP during the period 2018–2050 will be 3.5% on average**, which will result in a threefold increase in the GDP until the end of the period.[8] The household income will increase on average by 5–6% annually.

Mining, power generation and agriculture will slow down relative to other activities: agriculture will grow at an average annual rate of 2.3% and mining at a rate of 1.3%. Agriculture sector products will be more heavily targeted for processing internally in Ukraine, resulted in a fourfold increase in **food production** up to 2050 with average annual growth of up to 3.8%. The share of **mechanical engineering** will increase significantly, with vehicle production increasing more than eight times, computers and electronic and optical equipment more than seven times and electrical equipment more than six times. A slower increase in household incomes will limit the development of services, and this sector's share in the GDP will increase to 56%. Computer programming, consultancy and tourism-related services will show the largest growth among **services**.

The macroeconomic modelling results show minor changes in the structure of GVA until 2030 as this period is when industry will recover to the level of 2013. Thus, more evident changes in the output of goods and services can be observed in the long run (Table 2.1).

Table 2.1. Long-term economic projection

Indicators	2021–2030	2031–2040	2041–2050
GDP, %, average for period	3.8	3.5	3.2
Mining and quarrying, growth rate in %, average for period	2.0	1.2	0.6
Manufacturing, growth rate in %, average for period	4.5	4.2	3.8
Industry, growth rate in %, average for period	3.5	3.2	2.9
Construction, growth rate in %, average for period	5.0	4.3	3.9
Services, share in GDP, average for period, %	52.7	54.3	55.7
Agriculture, share in GDP, average for period, %	9.3	8.2	7.3

The actual GDP growth in Ukraine will depend on the successful implementation of structural reforms, product and geographical diversification of exports and, in particular, the development of the domestic market. This requires large-scale investments, and the growth rate of gross fixed

[7] Projection of the economic and social development of Ukraine for 2020–2022, adopted by the Cabinet of Ministers of Ukraine on 15 May 2019 (No. 555). https://zakon.rada.gov.ua/laws/show/555-2019-%D0%BF

[8] The updated NDC modelling process was launched in early 2019 and finished in 2020. During this time, the impact of the COVID-19 pandemic, resulting lockdown measures and following economic recovery on the energy system was not thoroughly studied and thus could not be properly considered in modelling. Meantime, the Baseline Macroeconomic Projection used in this study remains consistent with the recent economic statistics and the latest governmental projections published in 2021.

capital accumulation during 2020–2025 should reach at least 8–14% and that in 2021–2050 an average of 15–18%, while the rate of fixed capital accumulation to GDP should reach 20–24%, which is a prerequisite for accelerated economic growth.

As a result of the **termination of the violent conflict with the Russian Federation**, the Ukrainian economy will gain a strong impulse for development due to the extension of the domestic market and the need to restore the destroyed infrastructure in the Donbas region and in Crimea.

Demographic Projection

The macroeconomic projection prepared for the updated NDC predefined the prospective economic structure, corresponding energy use and GHG emissions and set the conditions for the prospective demographic development. For the purpose of this project, the Institute of Demography and Social Studies (NASU) updated its demographic projections in alignment with the available official statistics and the assumptions made for the macroeconomic projections described above.

Table 2.2. Long-term demographic projection

Indicators	2018	2030	2040	2050
Population, mln	42.4*	39.7	37.7	35.6
Average life expectancy, both genders, years	72.2	73.9	75.3	76.7
Average population age, both genders, years	40.5	42.7	44.4	45.4
Share of working-age population, both genders, %	51.1	48.4	47.5	43.0
Number of retired per working persons, both genders, persons	0.99	1.14	1.24	1.49
Share of rural population, %	32.6	31.6	30.2	28.6

** The population is aligned with data reported by the State Statistics Service of Ukraine and does not include the annexed territory of the Republic of Crimea. For the purpose of the NDC, these numbers have been correspondingly adjusted.*

International Energy Price Projection

Comprehensive energy price projection is as important as macroeconomic drivers or energy policy targets as different price dynamics for different energy resources determine the price parity between energy resources and thus may affect the economic viability of technologies or policy options in the future. For the purposes of this study, the International Energy Agency's forecast was used.[9]

Table 2.3. International energy price projection

Energy Source	2017	2020	2025	2030	2035	2040	2045	2050
Coal, EU, USD 2017/t	85	90	80	83	84	85	87	89
Brent oil, USD 2017/barrel	52	65	88	96	105	112	121	132
Natural gas, EU, USD 2017/mln BTU	5.8	6.0	7.8	8.2	8.6	9.0	9.4	9.9

[9] IEA. 2018. World Energy Outlook 2018. IEA, Paris. https://doi.org/10.1787/weo-2018-en

Key Assumptions

Table 2.4 summarizes the key assumptions that were imposed on the business as usual (S1), reference (S2) and climate-neutral economy (S3) scenarios.

Table 2.4. Key assumptions of the updated NDC scenarios

Key Input Parameters		2015	2030			2050		
			S1	S2	S3	S1	S2	S3
Economic parameters								
GDP, growth rate, %		-9.8	4.2			3.2		
Mining and quarrying, growth rate, %		-13.8	1.7			0.6		
Manufacturing, growth rate, %		-15.2	5.1			3.8		
Construction, growth rate, %		-18.4	5.3			3.9		
Services and transport, share in GDP, %			55.7			58.4		
Demographic parameters								
Population, mln		42.9	39.7			35.6		
Average life expectancy, years			73.9			76.7		
Average population age, years			42.7			45.4		
Share of working-age population, %			48.4			43.0		
Number of retired per working persons, persons			1.14			1.49		
Share of rural population, %		32.8	32.3			31.8		
Energy prices								
Energy sources	Brent oil, USD 2017/barrel	85	83			89		
	Coal, EU, USD 2017/t	52	96			132		
	Natural gas, EU, USD 2017/mln BTU	5.8	8.2			9.9		
Renewable energy (RE)								
Potential of renewable energy (RE), GW	Wind, *GW*	0.428	5		16	16		60
	Solar (ground), *GW*	0.359	9		16	36		90
	Solar (rooftop), *GW*	0.022	3		6	12		36
	Bioenergy, *mtoe*	2.1	30			42.1		
	Hydro (large), *GW*	5.9	6.3			6.3		
	Hydro (small), *GW*	0.09	0.250			0.375		
	Geothermal, *GW*	~0.0	0.4		0.8	0.6		1.4
Share of renewables (incl. hydro power plants) in TPES, %		3	>4	>17	>17	>4	>25	>25
Share of renewables (incl. hydro power plants) in power, %		6	>9	>13	>13	>9	>25	>25
Share of renewables in GFEC, %		5	>9	>17	>17	>9	>25	>25
Share of renewables in district heating, %		1	>10	>35	>35	>10	>40	>40
Energy efficiency (EE) targets								
Primary energy intensity, toe/$1000 GDP (PPP)		0.29	0.23	0.18	N/T	0.18	0.11	N/T
Primary energy (carbon-intensive resources) intensity, toe/$1000 GDP (PPP)		0.23	0.19	0.11	N/T	0.13	0.05	N/T
Energy losses								
Heat production losses, %		>20	N/T	11	<11	N/T	10	<10
Transportation electricity losses, %		12.1	N/T	8	<8	N/T	7	<7
Transportation gas losses, % of 2015		–	N/T	20	N/T	N/T	50	N/T
Power sector								
Implementation of Directive 2010/75/EU (integrated pollution prevention and control), %		NO	NO	85	100	NO	100	100
Share of balancing techs compare with wind/solar, %		NO	30/40			30/40		15/20
Accessibility of carbon capture and storage techs		N/A	N/A	N/A	AV	N/A	N/A	AV
Accessibility of fuel cell (FC) techs		N/A	N/A	N/A	AV	N/A	N/A	AV
Accessibility of new nuclear techs (small reactors)		N/A	N/A	N/A	AV	N/A	N/A	AV

Key Input Parameters		2015	2030			2050		
Building sector								
Share of energy savings in residential buildings, max. %			15	50	50	20	75	75
Share of retrofit in public buildings, max. %			15	50	50	20	75	75
Share of solar techs for heating in residential build., max. %		0	0.5	10	15	1.5	20	40
Share of solar techs for heating in public buildings, max. %		0	1.5	10	25	5	25	50
Share of solar techs for water heating in rsd buildings, max. %		0	1.5	10	15	5	25	50
Share of solar techs for water heating in public buildings, max. %		0	1.5	15	35	5	25	60
Industry								
Iron and steel, % of energy saving compared with S1			N/T	>10	M/R	N/T	>15	M/R
Ammonia, % of energy saving compared with S1			N/T	>10	M/R	N/T	>15	M/R
Pulp and paper, % of energy saving compared with S1			N/T	>10	M/R	N/T	>15	M/R
Cement, % of energy saving compared with S1			N/T	>15	M/R	N/T	>40	M/R
Glass, % of energy saving compared with S1			N/T	>15	M/R	N/T	>30	M/R
Lime, % of energy saving compared with S1			N/T	>25	M/R	N/T	>50	M/R
Other industries, % of energy saving compared with S1			N/T	>25	M/R	N/T	>50	M/R
TOTAL industry, % of energy saving compared with S1			N/T	>15	M/R	N/T	>30	M/R
Transport								
Electric vehicles, % of new vehicles purchased		0	2	10	>20	5	>20	>50
Hydrogen vehicles, % of new vehicles purchased		0	N/A	N/A	>0	N/A	N/A	>0
Share of alternatives fuels (including LPG, biofuels, electricity and hydrogen), %		9	15	>20	>50	>20	>25	>50
Share of alternative fuels (including LPG, biofuels, electricity and hydrogen) in urban public transport, %		9	15	>20	>50	>20	>25	>50
Share of hydrogen transport in urban public transport, %		0	N/A	N/A	>0	N/A	N/A	>0
GHG emission targets								
Total CO_2 equivalent emissions with land use, land use change and forestry, Mt CO_2eq		310.2	N/T	N/T	<S2	N/T	N/T	<60
Carbon intensity	CO_2 eq. per capita	7.2	M/R	M/R	<S2	M/R	M/R	<1.7
	CO_2 eq./1000 GDP (PPP)	1.0	M/R	M/R	<S2	M/R	M/R	<0.1
Waste sector								
MSW generation per capita, tons/capita/year		0.33	0.39	0.39	0.39	0.48	0.48	0.48
Share of MSW landfilling, % of generation		94.4	93.4	30	10	93.4	20	5
Landfill methane utilization, % of landfill methane generation		3.5	4.5	23	30	4.5	36	63
Water supply intensity, compared with 2015 in %		100	100	70	60	100	50	35
Agriculture sector								
Cattle population, mln heads		2.7	3.7			4.05		
Poultry population, mln heads		217.4	257.3			282.5		
Methane removal by biogas production facilities from total methane produced from manure, %		0	0	16	31	0	25	50
Area of organic crop production, mln ha		0.27	0.27	0.96	1.75	0.27	2.0	4.0
Land use, land use change and forestry (LULUCF)								
Forest cover, % of total area of Ukraine		16.1	16.2	17	17	16.5	20	20
Yearly afforestation, thousand ha		5.23	7.8	60.4	60.4	7.8	90.5	90.5
Share of final clearance, % of 2015		100	100	83	83	100	50	50
Area of cropland and grassland, mln ha		28.8	30.1			31.3		
Efficiency of synthetic N fertilizer application, % of 2015		100	100	110	113	100	130	140

Acronyms: ***S1*** *– Scenario 1 (business as usual or barrier scenario);* ***S2*** *– Scenario 2 (reference scenario or current policy scenario one);* ***S3*** *– Scenario 3 (alternative scenario or climate-neutral economy scenario);* ***TPES*** *– total primary energy supply;* ***GFEC*** *– gross final energy consumption;* ***GDP*** *– gross domestic product;* ***PPP*** *– purchasing power parity;* ***NO*** *– not implemented or no constraints;* ***N/T*** *– no targets in a scenario;* ***N/A*** *– not available in a scenario;* ***AV*** *– available in a scenario;* ***M/R*** *– modelling results.*

Carbon Pricing

The Emission Trading Scheme (ETS) was established by the EU ETS Directive 2003/87/EU included in the Association Agreement between Ukraine and the EU. At the moment, it is still difficult to estimate a clear time frame within which the Ukrainian ETS will be introduced. This is due to both political and administrative objective difficulties, such as the delay in introducing a new power market model (summer 2019), the inability to cover fully plants with annual GHG emissions of 200 Mt CO_2-eq. in the Crimea and Donbass regions and the incompleteness of the regulatory framework.

Given the high level of uncertainty about the timing of the full introduction of the ETS in Ukraine, its organizational framework and its participants, it is quite difficult to estimate the prospective carbon price to be set by the market. For this reason, the introduction of the ETS (carbon pricing) was not considered in scenarios 2 and 3. Instead, the impact of the carbon price was evaluated in the combined sensitivity scenario.

Input Data for the combined sensitivity scenario

The combined sensitivity scenario was modelled on the baseline economic development scenario, including the conditions of Scenario 2 for the sectors of agriculture and land use, land use change and forestry (LULUCF) as well as the sensitivity options, such as:

- Carbon tax:
  - For an in-depth study, a range of carbon tax values that cover all energy users, exploring the sensitivity of the solution to the GHG emission prices, should be used, but, in this study, in the combined sensitivity scenario, we used only one carbon tax trajectory based on the value of carbon tax in the PMR report (18 US dollars or ~15.6 euros per t CO_2) in 2030 and extrapolated to 100 euros per tonne of CO_2 in 2050.
- New trajectory of greenhouse gas emission limits until 2050 (15% of 1990):
  - The combined sensitivity scenario forecasts that GHG emissions (including the LULUCF sector) will be relatively the same as in Scenario 3 during the period of 2020–2040 and less in 2045–2050 according to the input assumptions, reaching 14–15% of the 1990 level in 2050 (6% in Scenario 3). This GHG emission pathway in the combined sensitivity scenario corresponds to the IEA's scenario.
  - This sensitivity option was proposed by the Ministry of Environmental Protection and Natural Resources of Ukraine (at that time – Ministry of Energy and Environmental Protection of Ukraine), considering the huge increase in investment needs in the last decade in Scenario 3.
- Higher (global and European) capital investments for the construction of new nuclear power plant units:
  - Large nuclear units (incl. new units #3 and #4 at the Khmelnyts'ka nuclear power plant) – 5922 euros (~7000 US dollars) per kW (EU benchmark).
- Extension of the lifetime of existing nuclear power plant units:
  - Based on Energoatom information for some existing nuclear reactions, the lifetime can be extended for an additional 5–10 years.

- Current availability factor for existing and new nuclear power plant units:
  - Based on Energoatom information on the use of 76% of the availability factor for all new large units of nuclear power plants.
- Lower balancing capacity requirements:
  - Additional large hydro pump storage of 1.7 GW.
  - Minimum balancing technologies related to variable renewables (solar and wind, excl. roof solar panels):
    - 1% in 2020 and 10% in 2050 of the battery storage of new variable renewables' capacity;
    - 10% in 2020 and 0% in 2050 of balancing techs (gas, hydro, fuel cells and imports) of new VRE capacity based on learning technologies.
- Limited implementation of waste sector policy inputs:
  - Share of MSW landfilling in 2030 as a percentage of the generated MSW.
  - Share of the population covered by the centralized collection MSW system in 2030.
  - Number of new regional sanitary MSW landfills to be constructed in units for the period 2020–2030.
  - Number of existing MSW landfills to be modernized to the level of sanitary in units for the period 2020–2030.

2.4 MODELLING RESULTS

Detailed modelling results of the project are presented in Report 3: Modelling Report[10] and Report 4. Part A: Policies and Measures,[11] which are available on the website of the Ministry of Environmental Protection and Natural Resources of Ukraine.[12] In general, the modelling results show that the GHG emissions (including those in the LULUCF sector) are consistent with the IEA and IPCC scenarios for the 2050 pathway only in Scenario 3 and the combined sensitivity scenario (Figure 2.2). The GHG emission reductions compared with the 1990 level by scenario are presented in Table 2.5.

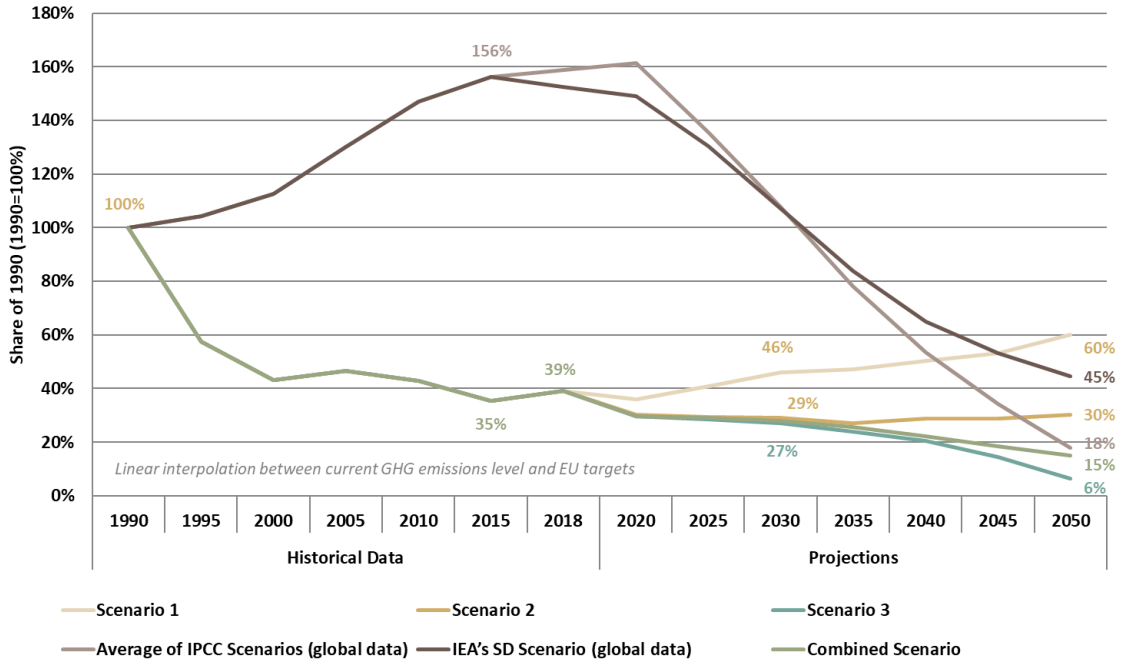


Figure 2.2. GHG emission reduction pathways by updated NDC scenario

Figure 2.3 shows how Ukraine's climate commitments (in the first and second periods of the Kyoto Protocol, the first and updated NDCs, the Energy Strategy of Ukraine until 2035 and the Low Emission Development Strategy until 2050) corresponded to the actual trajectory of GHG emissions and how the combined sensitivity scenario corresponds to the theoretical trajectory to reach carbon neutrality by 2070.

Figure 2.3 also shows the trajectory of GHG emissions with a new target for 2030 and carbon neutrality in 2060, which was initially presented in the draft updated NDC of Ukraine by the Ministry of Environmental Protection and Natural Resources of Ukraine. The new updated NDC target in 2030 is less ambitious than that in the modelling results for the combined sensitivity scenario but more ambitious than that in the reference scenario. In addition, Figure 2.3 shows how much more the EU, Poland, the USA and Canada in particular need to undertake to achieve their new goals and indicates that the goal of achieving carbon neutrality is an easier task for Ukraine.

[10] Report 3: Modelling Report. 2020. EBRD Project "Support to the Government of Ukraine on Updating its Nationally Determined Contribution (NDC)". Retrieved from: https://mepr.gov.ua/files/images/news_2020/15052020/1ukraine%20ndc2_modelling_report_3_final.pdf

[11] Report 4. Part A: Policies and Measures. 2021. EBRD Project "Support to the Government of Ukraine on Updating its Nationally Determined Contribution (NDC)". Retrieved from: https://mepr.gov.ua/files/images/2021/29042021/Policies%20and%20Measures%20Report%204.A.pdf

[12] https://mepr.gov.ua/en/

Table 2.5. GHG emissions in the updated NDC scenarios: modelling results

Sector	#	Scenario	GHG Emission Reduction from the 1990 Level (Share of the 1990 Level)		
			2018	2030	2050
Energy and industrial process sectors	**1**	BAU scenario	**-66%** (34% level)	**-57%** (43% level)	**-45%** (55% level)
	2	Reference scenario		**-74%** (26% level)	**-70%** (30% level)
	3	Climate-neutral economy scenario		**-75%** (25% level)	**-93%** (7% level)
	4	Combined sensitivity scenario		**-75%** (25% level)	**-86%** (14% level)
Agriculture sector	**1**	BAU scenario	**-49%** (51% level)	**-52%** (48% level)	**-52%** (48% level)
	2	Reference scenario		**-54%** (46% level)	**-56%** (44% level)
	3	Climate-neutral economy scenario		**-56%** (44% level)	**-60%** (40% level)
	4	Combined sensitivity scenario		**-54%** (46% level)	**-56%** (44% level)
LULUCF* sector	**1**	BAU scenario	**+104%***	**+95%** (5% level)	**+105%***
	2	Reference scenario		**+79%** (21% level)	**+59%** (41% level)
	3	Climate-neutral economy scenario		**+69%** (31% level)	**+39%** (61% level)
	4	Combined sensitivity scenario		**+79%** (21% level)	**+59%** (41% level)
Waste sector	**1**	BAU scenario	**+2%** (102% level)	**+7%** (107% level)	**+23%** (123% level)
	2	Reference scenario		**-18%** (82% level)	**-49%** (51% level)
	3	Climate-neutral economy scenario		**-35%** (65% level)	**-81%** (19% level)
	4	Combined sensitivity scenario		**-15%** (85% level)	**-66%** (34% level)
Economy wide	**1**	BAU scenario	**-66%** (34% level)	**-54%** (46% level)	**-40%** (60% level)
	2	Reference scenario		**-71%** (29% level)	**-70%** (30% level)
	3	Climate-neutral economy scenario		**-73%** (27% level)	**-94%** (6% level)
	4	Combined sensitivity scenario		**-72%** (28% level)	**-85%** (15% level)

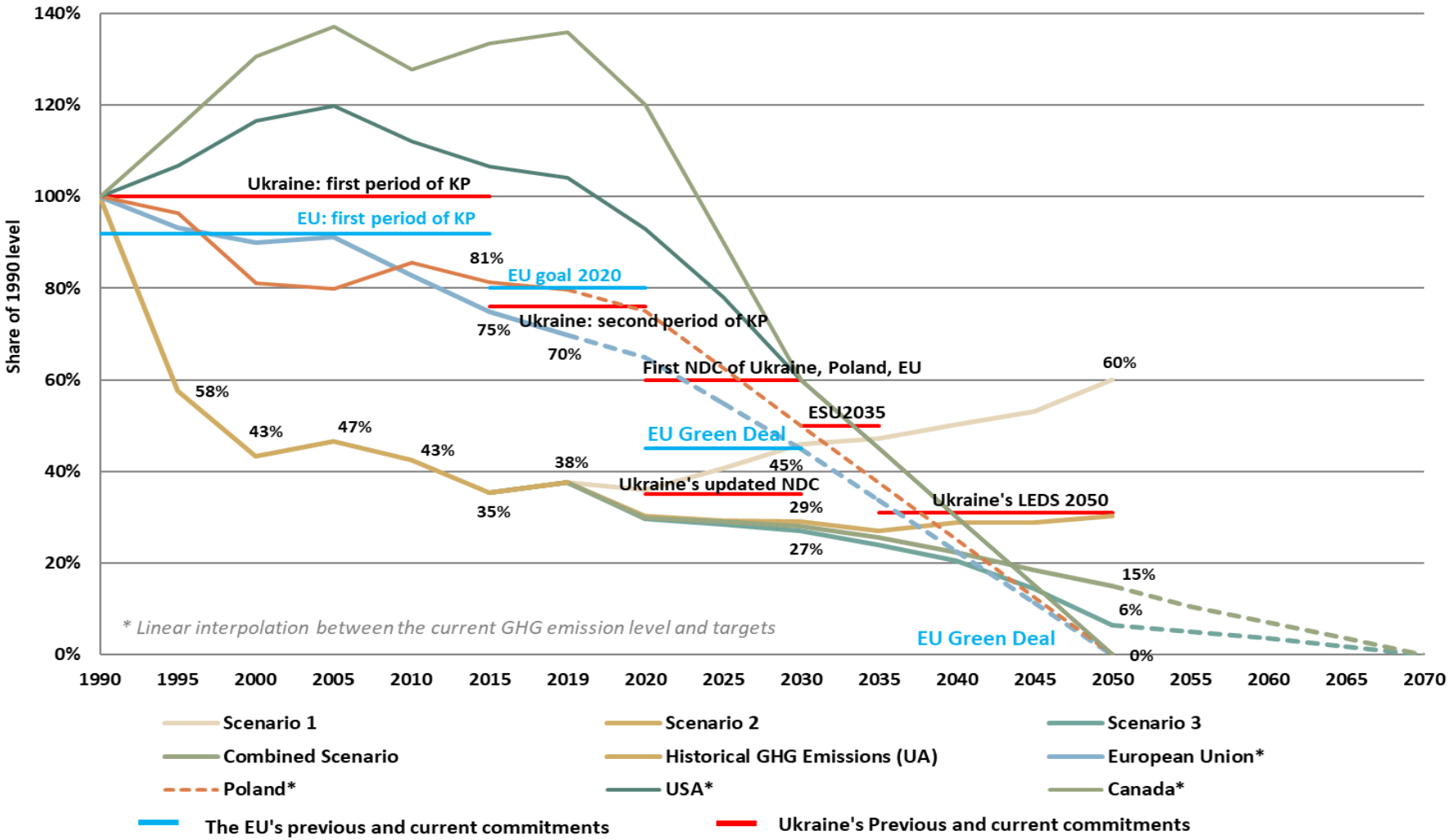


Figure 2.3. GHG emissions in Ukraine, the EU and selected countries

As shown in Figure 2.4, the investment needs excluding consumer spending (top left) in the combined sensitivity scenario will be approximately at the level of Scenario 2, while they are significantly higher in Scenario 3, and there are particularly high investment needs in 2050 in Scenario 3 (top right), which was one of the reasons for developing the combined scenario. The total system cost (excluding the cumulative amounts of CO_2 tax) for the period 2020–2050 are more or less the same for each of the four scenarios (bottom left). Moreover, the total system costs of the combined sensitivity scenario are lower than those in Scenario 2 and only 0.3% higher than those in Scenario 1 (bottom right), which means that the implementation of a climate-neutral policy could cost about the same as that of the business as usual policy.

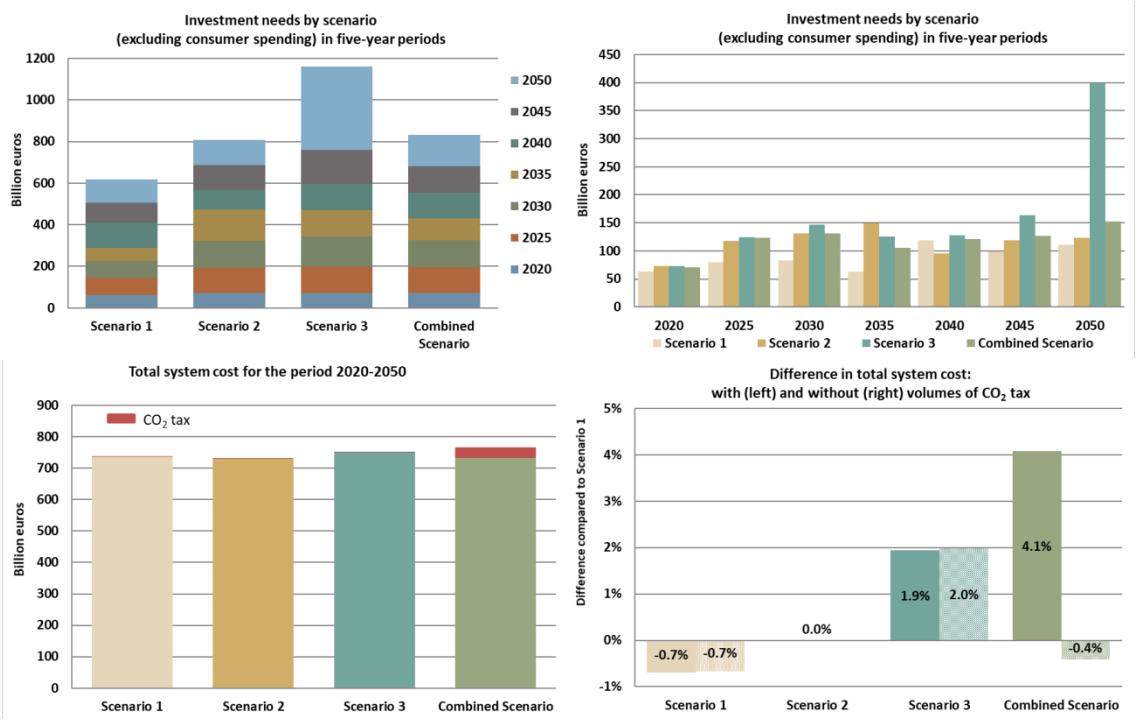


Figure 2.4. Ukraine's updated NDC scenarios: investment needs[13]

Table 2.6 presents the GHG emissions and investment needs (including consumer spending) in 2030 and 2050 by key IPCC sectors and economic subsectors.

The share of RE in the electricity production in 2050 is almost twice as high (87% vs. 45%) and in TPPs it is more than 2.5 times higher (53% vs. 20%) (see Figures 2.5–2.6). The higher CAPEX based on the international benchmark and the lower load factor in line with the current one in Ukraine are crucial points for the future development of nuclear energy in Ukraine. Under these conditions, the share of nuclear energy may decrease to 11% in the combined scenario, even with the extension of the lifetime of existing nuclear units by an additional 5–10 years, while, in Scenarios 2 and 3, the share of nuclear power plants in the total electricity production will be 41–43% in 2050. In Scenario 3 and the combined scenario, the coal phase-out should take place before 2050 (Figure 2.5).

[13] Investment here includes only the cost of energy production and use technologies, some of which can be interpreted as final consumer costs, production or other costs. The total cost of energy system operation is the sum of the discounted annual capital investment (including service life), operational costs, costs of production and supply (import) of energy resources, taxes and subsidies (e.g. CO_2 tax and "green tariffs") and so on, but it does not include population utilities or coal mines' state support.

Table 2.6. GHG emissions and investment needs in the combined scenario

	Historical Data			Combined Sensitivity Scenario			
	GHG Emissions, Mt CO_2-eq.			GHG Emissions, Mt CO_2-eq.		Investment Needs, Billion euros	
	1990	2015	2018	2030	2050	2021–2030	2021–2050
TOTAL (net emissions)	**883**	**313**	**342**	**247**	**130**	**379**	**1164**
1+2. Energy + industrial processes and product use	843	267	282	210.7	114.0	370.3	1143.1
Electricity and heat*	*273*	*90*	*99*	*52.9*	*2.4*	*26.0*	*138.5*
Industry*	*229*	*75*	*75*	*81.3*	*79.4*	*37.3*	*130.7*
Buildings*, **	*98*	*29*	*28*	*21.5*	*7.5*	*85.7*	*266.2*
Transport*, **	*112*	*31*	*35*	*20.1*	*12.2*	*208.3*	*578.1*
Supply sector*	*127*	*41*	*46*	*31.8*	*12.2*	*10.8*	*23.7*
Agriculture*	*3.8*	*0.3*	*0.4*	*3.1*	*0.3*	*2.2*	*5.9*
3. Agriculture	87	39	44	38	36	4.0	3.6
4. Land use, land use change and forestry	-59	-6	3	-12	-24	2.9	2.6
5. Waste	12	12	12	10	4	2.3	14.2
Others	0.1	0.4	0.5	0	0	0	0

** Economic sectors; ** investment needs include consumers' spending, such as of buying vehicles, advanced housing equipment (washing machines, refrigerators, individual heat boilers, etc.) and others.*

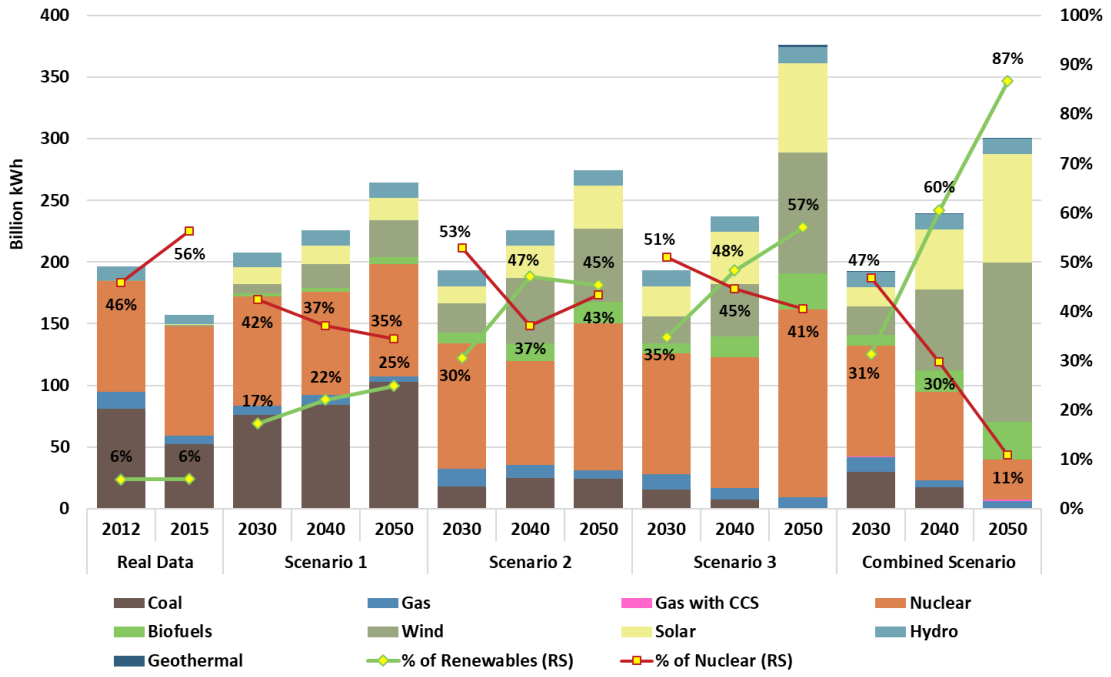


Figure 2.5. Electricity production by updated NDC scenario

In the TPES, renewable energy will account for about 50% of bioenergy, and the other 50% will be solar and wind energy. The consumption of natural gas in 2050 in the combined scenario will be about 25 billion m^3 and will mainly occur in industry (61%), including 47% as non-energy consumption and 13% in the residential sector, and the other sectors will consume around 5–6% of the total gas consumption (Figure 2.6).

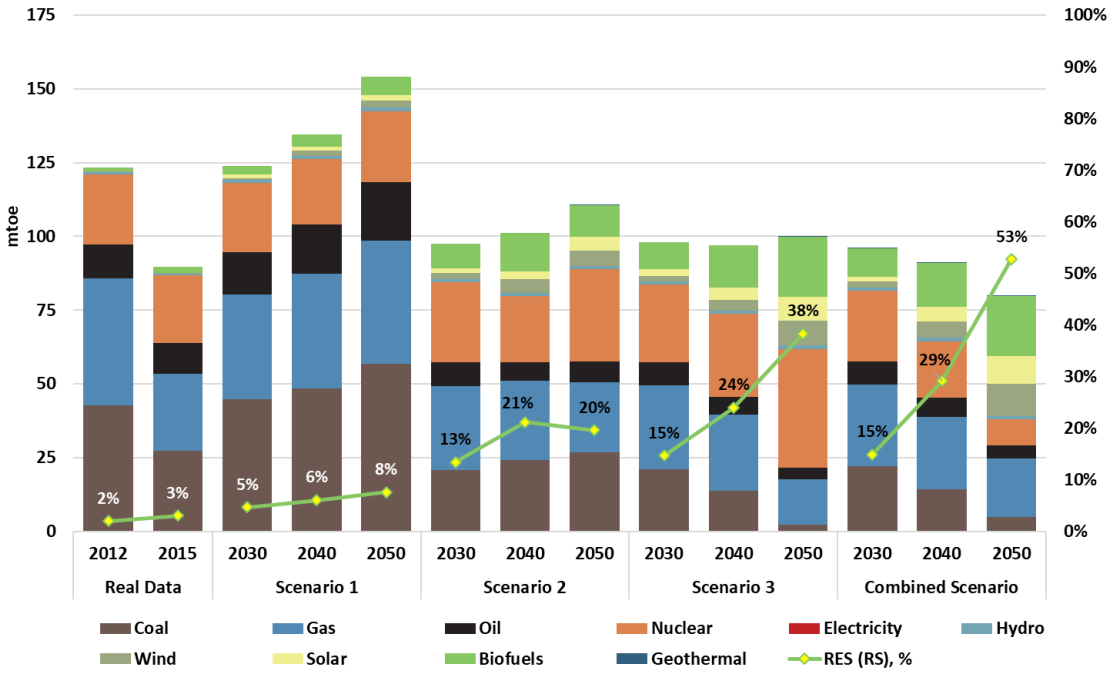


Figure 2.6. Total primary energy supply by updated NDC scenario

Although the GHG emission reductions in the combined scenario are greater than those in Scenario 2, the investment needs (without consumers' spending) are close (Table 2.7).

Table 2.7. GHG emissions, investment needs and share of RE in the updated NDC scenarios

Scenario Name	GHG Emission Reduction Compared with the 1990 Level		Investment Needs (without Consumers' Spending), Billion Euros		Renewable Energy Share			
					Electricity Production		TPES	
	2030	2050	2021–2030	2021–2050	2030	2050	2030	2050
Business as usual	-54%	-40%	202	671	17%	24%	5%	8%
Reference	-71%	-70%	241	731	30%	45%	13%	20%
Climate-neutral economy	-73%	-94%	256	971	34%	56%	15%	38%
Combined sensitivity	-72%	-85%	263	798	31%	87%	15%	53%

The implementation of the combined sensitivity scenario requires the attraction of 26 bln euros annually, which is approximately 70–80% of all capital investments. That is, **the average capital investment in 2020–2030 should be 28–33 bln euros annually, which is 40–65% more than the level of capital investment in 2019 but corresponds to the data of 2007–2008**.

As a result of the extensive, inclusive and transparent stakeholder consultation process on scenarios of the Ukrainian updated NDC conducted between June 2019 and November 2020 within the framework of the NDC Development Working Group and other multiple formats of consultations, MinEcology informed the project that NDC implementation policies and measures should be developed based on Scenario 4, the so-called **combined sensitivity scenario**. As the next step, the project developed a set of policies and measures that need to be implemented to achieve the combined sensitivity scenario target.

Carbon Budget

The term carbon budget is used in this report to refer to the cumulative amount of GHG emissions budgeted to be emitted over a period of time. Graphically, the carbon budget can be presented as the area of the figure outlined below the emission curve, as shown in Figure 2.7 as the highlighted area.

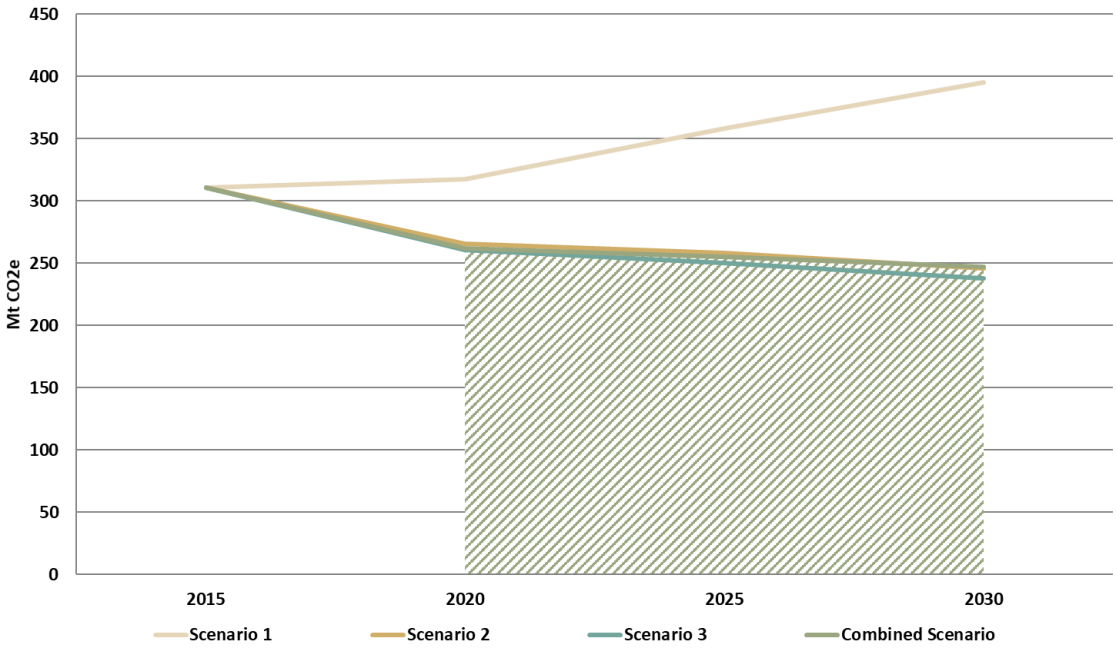


Figure 2.7. Carbon budget by updated NDC scenario

Except in Scenario 1, all the updated NDC scenarios follow a similar trajectory until 2030, and the estimated carbon budget or cumulative GHG emissions for these scenarios are similar to one another. The difference between Scenario 1 and the other scenarios – or, alternatively, the difference between the average annual emissions and the 2015 level and the same difference of emissions in 2030 – reflects the level of ambitions and the expected contribution of each sector to meeting the policy assumptions. **Fuel combustion, fugitive emissions and industrial processes (IPCC categories) remain the biggest GHG emitters, accounting for about 86%**.

Conversely, the structure of emissions by sub-sector differs among scenarios. Extensive economic/energy system development in **Scenario 1 provides no radical changes in the structure of energy consumption or emissions by sector within the period 2021–2030** (see Modelling Report 3). This leads to the conclusion that the sectoral allocation of the carbon budget in Scenario 1 estimated for 10 years is likely to reflect today's structure of emissions throughout the time frame, that is, without notable distortion at the beginning or end of the period. **In the other updated NDC scenarios, in which the decarbonization of the energy sector plays a crucial role in reaching the emission reduction target, the composition of emissions from fuel use by sector in 2030 and the respective breakdown of the carbon budget differ from those of today** (Figure 2.8).[14]

[14] In the TIMES-Ukraine model, GHG emissions are counted by economic activities; thus, the allocation of GHG emissions to the *energy and industrial process sectors* (IPCC categories) presented here is also made according to **economic activities**, which is consistent with the European environmental economic accounts used by Eurostat. In Ukraine, GHG emissions are normally not reported by economic activities, so the assessment of GHG emissions by economic sector for 2015 was taken from the TIMES model just *for comparison purposes*.

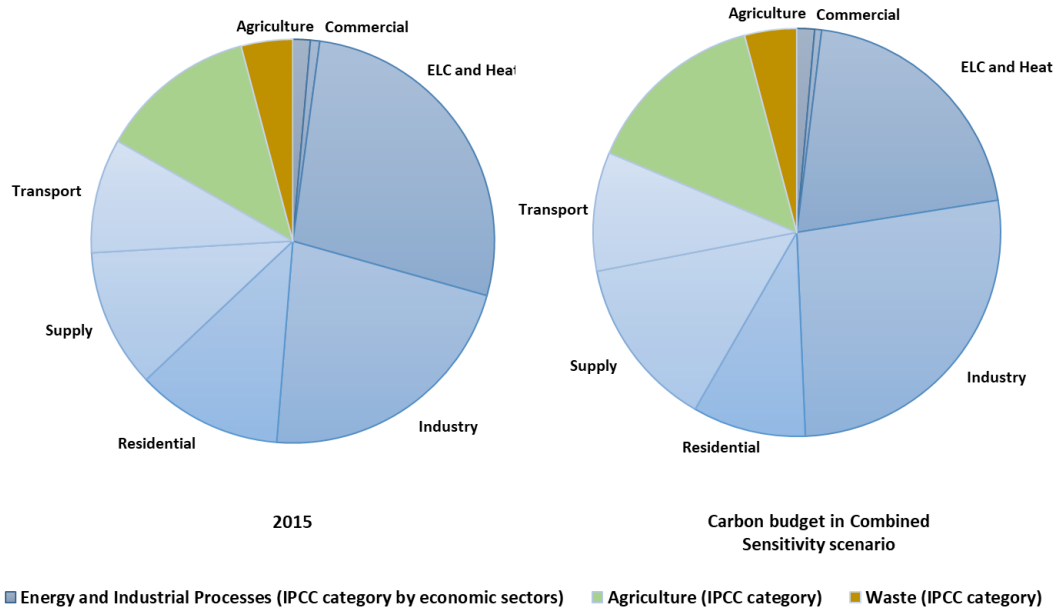


Figure 2.8. GHG emissions in the combined scenario by sector

The expected decrease in emissions by almost 40% in the electricity and heat production and buildings sectors in 2030, compared with 2015, explains the drop in the share of these sectors from 26% to 20% and from 12% to 10%, respectively. Meanwhile, owing to optimistic assumptions that agriculture and industrial production (manufacturing) should double by 2030, the share of industry (as the economic sector) increases from 21% to 28% and agriculture (as the IPCC category) increases from 12% to 15%.

Fairness of the Ukraine's NDC Commitment

The main goal of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping the global temperature increase well below 2 °C by the end of the century relative to the pre-industrial level.[15] The Paris Agreement architecture of parties' contributions is based on the bottom-up approach, which foresees regular self-determined submissions of such contributions by each party. At the same time, the fairness of each nationally determined contribution should be addressed, and this fairness is not defined by the Paris Agreement. There are numerous research papers and reports on the issue of addressing fairness and equity concepts and its principles. Several studies have modelled the allocation of the 2 °C- and 1.5 °C-consistent global carbon budgets to countries using different equity principles.[16, 17] Different concepts of fairness have been proposed and discussed, showing substantial variation in effort sharing between different approaches.[18, 19, 20]

[15] UNFCCC. 2020. The Paris Agreement. Paris Agreement: Essential Elements. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[16] Robiou du Pont, Y., Jeffery, M., Gütschow, J. et al. 2017. Equitable mitigation to achieve the Paris Agreement goals. Nature Clim. Change 7, 38–43. https://doi.org/10.1038/nclimate3186
[17] Peters, G. P., Andrew, R. M., Solomon, S. and Friedlingstein, P. 2015. Measuring a fair and ambitious climate agreement using cumulative emissions. Environ. Res. Lett. 10, 105004.
[18] State Fiscal Service of Ukraine (SFSU). 2020. Tax Code of Ukraine. Section VIII. Ecological Tax. http://sfs.gov.ua/nk/rozdil-viii--ekologichniy-poda/
[19] Tørstad, V. and Sælen, H. 2018. Fairness in the climate negotiations: what explains variation in parties' expressed conceptions? Climate Policy 18:5, 642–654. DOI: 10.1080/14693062.2017.1341372
[20] Höhne, N., den Elzen, M. and Escalante, D. 2013. Regional GHG reduction targets based on effort sharing: a comparison of studies. Clim. Policy 14, 122–147.

To assess the mitigation targets for Ukraine proposed under Scenarios 2 and 3, we compared them with the fair share of Ukraine's mitigation effort under five equity approaches, which follow the five IPCC-AR5 equity categories.[21] Table 2.8 below provides an overview of such principles.

Table 2.8. Approaches to the allocation of the global carbon budget by countries

Allocation Code	Allocation Name	IPCC Category	Allocation Characteristics
CAP	Capability	Capability	High mitigation for countries with a high GDP per capita
EPC	Equal per capita	Equality	Convergence towards equal annual emissions per person
GDR	Greenhouse development rights	Responsibility–capability–need	High mitigation for countries with a high GDP per capita and high historical per capita emissions
CPC	Equal cumulative per capita	Equal cumulative per capita	High mitigation for countries with high historical per capita emissions
CER	Constant emission ratio	Staged approaches	Maintains the current emission ratios

Source: Robiou du Pont et al. (2017).

Table 2.9. Comparison of the Ukrainian climate mitigation efforts under different equity principles and the Ukrainian targets for the first and updated NDCs, emission change w.r.t. 2010, %

Allocation Code	Allocation Name	2 °C Consistent	1.5 °C Consistent	Scenario 2	Scenario 3	First Ukrainian NDC
CAP	Capability	-57	-70	-34.6	-36	+39
EPC	Equal per capita	-36	-54	-34.6	-36	+39
GDR	Greenhouse development rights	-50	-67	-34.6	-36	+39
CPC	Equal cumulative per capita	64	40	-34.6	-36	+39
CER	Constant emission ratio	-5	-33	-34.6	-36	+39
Average over five allocation approaches		**-17**	**-37**	**-34.6**	**-36**	**+39**
Climate Action Tracker (all)		**-28.7**	**-46.8**	**-34.6**	**-36**	**+39**

Notes: All the emission estimates exclude LULUCF. The Climate Action Tracker used six different effort-sharing approaches. For the 2 °C scenario, we used the level of emissions that corresponds to the limit between 2 °C compatible and insufficient. For the 1.5 °C scenario, we used the level of emissions that corresponds to the limit between 1.5 °C Paris Agreement compatible and 2 °C compatible.

In the "Scenario 2" and "Scenario 3" columns, the cells highlighted in light green correspond to the cases that are consistent with the 2 °C mitigation efforts and the cells highlighted in dark green correspond to the cases that are consistent with the 1.5 °C mitigation efforts.

Source: Developed by the authors based on the estimates of GOU (2015),[22] Robiou du Pont et al. (2017) and the TIMES-Ukraine model.

Robiou du Pont et al. (2017) provided estimates of the emission reduction targets for 174 countries, including Ukraine, under each of the carbon budget allocation approaches listed in Table 4. Table 5 compares the estimates of the emission reduction targets for Ukraine sourced from Robiou du Pont et al. (2017) with the estimates developed for the updated Ukrainian NDC.

[21] Clarke, L. et al. 2014. In Climate Change 2014: Mitigation of Climate Change (eds Edenhofer, O. et al.) 456–462. IPCC, Cambridge Univ. Press.
[22] Government of Ukraine (GOU). 2015. Intended Nationally-Determined Contribution (INDC) of Ukraine to a New Global Climate Agreement.
http://www4.unfccc.int/ndcregistry/publisheddocuments/ukraine%20first/ukraine%20first%20ndc.pdf

We have also added estimates of Ukraine's fair share contribution, as estimated by the Climate Action Tracker (CAT)[23] for Ukraine's existing first NDC.

The comparisons with the five approaches of Robiou du Pont et al. (2017), as well as the Climate Action Tracker estimates, suggest that **both Scenario 2 and Scenario 3 (hence the combined sensitivity scenario as well) are consistent with the well-below 2 °C mitigation efforts**, although they are **not quite ambitious enough to reach 1.5 °C consistency**.

Scenario 3 is 1% different from the 1.5 °C-consistent mitigation effort for Ukraine, as suggested by Robiou du Pont et al. (2017). Table 2.9 also shows that the first Ukrainian NDC is highly insufficient, according to the estimates of both the CAT and Robiou du Pont et al. (2017). Only under one equity principle option (equal cumulative per capita) could the first Ukrainian NDC commitment be considered consistent with the 2 °C mitigation efforts.

2.5 ECONOMIC IMPACT ASSESSMENT

In Report 3, we provided an assessment of the potential economic impacts of the climate mitigation scenarios in Ukraine. In this section, we summarize the corresponding findings, while, for further details, interested readers are referred to Report 3.

The general approach to the economic impact assessment included the setting up of the baseline scenario (Scenario 1), which, in the case of the adopted approach, included the calibration of the sectoral GDP growth rates as well as the replication of the baseline TIMES-Ukraine energy and emission profiles. Two emission scenarios were considered for the economic assessment: Scenario 2 and Scenario 3. In terms of the emission reductions under the policy scenarios, emissions are reduced by 40.1% in 2030 (relative to the baseline – Scenario 1) in both Scenario 2 and Scenario 3. In 2050, emissions are reduced by 46.6% in Scenario 2 (relative to Scenario 1) and by 87.8% in Scenario 3.

For each emission reduction scenario (Scenarios 2 and 3), five policy scenarios (options) were considered: (a)–(e). The choice of this set of scenarios was driven by the aim of exploring two key scenario dimensions: (a) carbon revenue recycling options and (b) energy efficiency improvement potential.[24] Both scenario dimensions have proven to be critical in shaping the economic outcomes of the mitigation policies, as previous studies have suggested. In addition, a scenario that explores the option of CO_2 export permits in the Ukrainian natural gas sector was considered. In each of the explored scenarios, the carbon reduction target identified in Scenarios 2 and 3 is achieved *using carbon pricing of all fossil fuel combustion activities, but different additional policy options are used to reach this target*.

Table 2.10 provides a summary of the considered policy options. It should be noted that, while the considered scenarios explore two critical dimensions of the climate mitigation policy implementation, numerous other exploratory scenarios could be constructed, deepening and extending the set of options considered.

[23] Climate Action Tracker (CAT). 2020. Ukraine. https://climateactiontracker.org/countries/ukraine/

[24] Energy efficiency improvements were parametrized using estimates provided by the TIMES-Ukraine model and represent a reduction in the energy use (by fuels) per production of a unit of the commodity, for instance the change in consumption of natural gas to produce 1 kWh of electricity at the natural gas power plants.

Table 2.10. Policy implementation options for the economic impact assessment

Policy Option	Energy Efficiency Change Assumptions	Carbon Tax Revenue Redistribution Assumptions	Additional Assumptions
(a)	Energy efficiency changes are implemented from the TIMES-Ukraine model	Carbon tax revenue is used to fund investment requirements; excessive carbon tax revenue is redistributed to households	No
(b)	Energy efficiency changes are implemented from the TIMES-Ukraine model	Carbon tax revenue is used to fund investment requirements; excessive carbon tax revenue is redistributed to households	The Ukrainian gas sector exports 10 million t CO_2 at a price of 20 euros per t/CO_2
(c)	Energy efficiency changes follow Scenario 1	Carbon tax revenue is used to fund investment requirements; excessive carbon tax revenue is redistributed to households	No
(d)	Energy efficiency changes follow Scenario 1	Carbon tax revenue is allocated to the government	No
(e)	Energy efficiency changes follow Scenario 1	Carbon tax revenue is allocated to households	No

Investment Boost and Energy Efficiency Improvements

Policy option "a" can be considered as the most optimistic of the emission reduction policies as both the economy and the environment will benefit significantly from such a scenario. According to our estimates, in this policy scenario, the GDP grows by around 14%–16% in 2050 relative to the baseline, depending on the scenario (Figure 1). Due to the higher level of investments and energy efficiency improvements, as well as the relatively low cost of carbon reductions before 2035–2040, the GDP grows at a much faster pace in Scenario 3 than in Scenario 2. At the same time, after around 2035, following a higher level of carbon reduction ambitions, additional GDP growth rates in Scenario 3 slow down.

A qualitatively similar trend can be observed for households' income (Figure 2.9), although, in this case, Scenario 2 results in a higher growth rate. Residential consumers face much higher carbon prices in Scenario 3, which affects their cost of consumption. At the same time, even in the 2040–2050 time frame, when the carbon prices in Scenario 3 exceed 100 US dollars/ton CO_2-eq. and reach 1300 US dollars/ton CO_2-eq. in 2050, residential users still experience an increase in real income relative to Scenario 1. Energy efficiency improvements play a key role in making this possible as they significantly reduce production costs and lower prices for households.

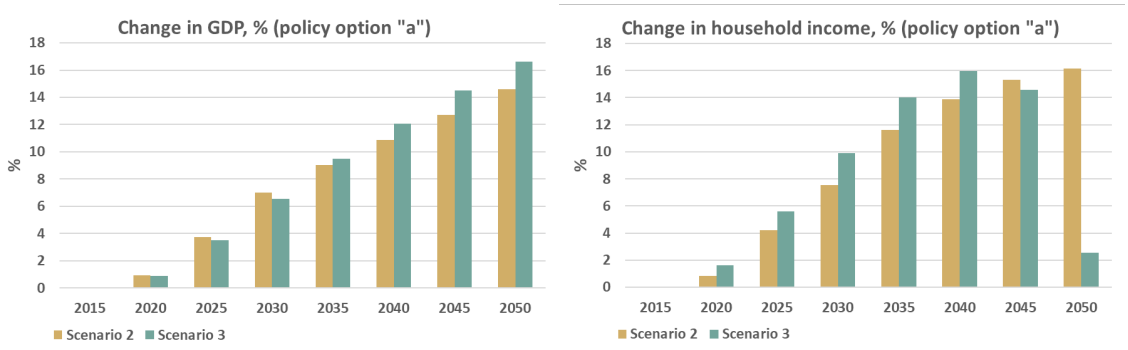


Figure 2.9. Change in the GDP and income under policy option "a": investment boost and energy efficiency improvements

At the sectoral level, there are significant transformations in the output structure, which result in the substantial reduction of the GDP carbon and energy intensity. This is especially the case for Scenario 3, in which the production of coke and coal falls by over 75% in 2050 relative to the baseline. Other energy-intensive sectors, such as basic metal production, petroleum production and utilities, also significantly reduce their output in Scenario 3 (Figure 2.10). At the same time, a shift towards services and sectors that are heavily involved in investment generation processes is observable. The latter case includes an increase in the output of the programming sector and research and development activities. The construction sector increases its output as a key supplier of investment goods. The increasing output of the food and agricultural sectors is driven mainly by increasing exports of these commodities. Some other final consumption goods, such as clothing and machinery and equipment, experience output growth due to the increasing final demand.

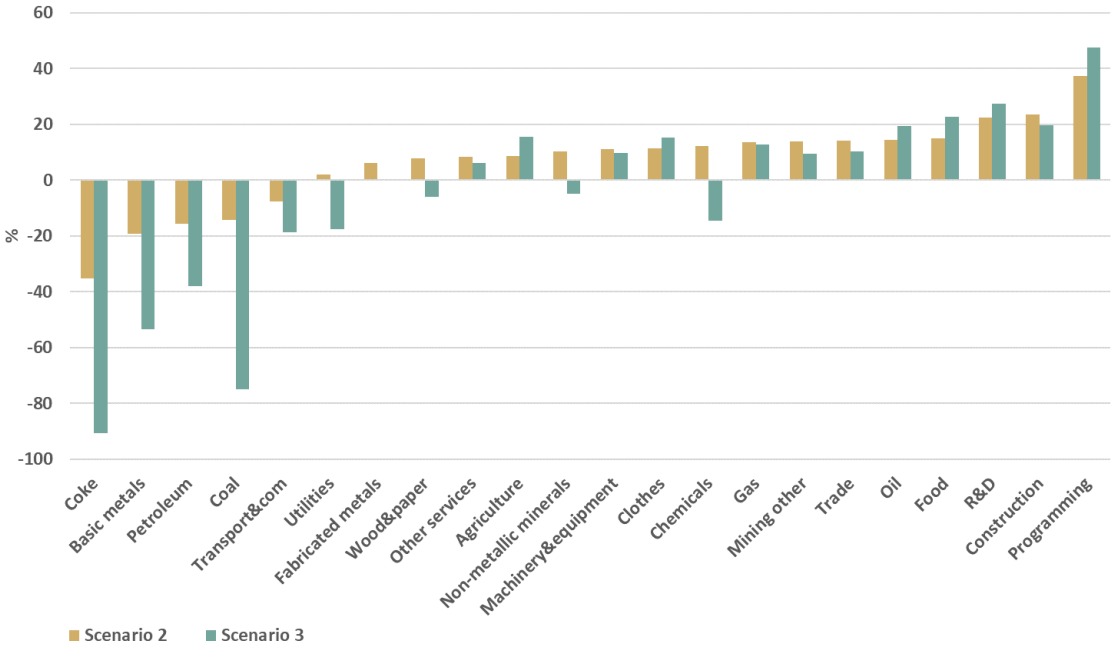


Figure 2.10. Change in sectoral output in 2050 under policy option "a": investment boost and energy efficiency improvements

While the investment-intensive pathway with investments allocated to energy-efficient technologies could be considered as the most attractive from both the macroeconomic and the sectoral perspective, our analysis does not capture some of the possible risks and uncertainties associated with this scenario. In particular, it was assumed that all the investments within this pathway are allocated to the domestic economy, which is one of the key sources of the observed economic growth. The impacts might not be so positive if a large share of capital goods is purchased from abroad.

Another critical assumption is that, under increasing carbon taxes, producers and consumers not only shift their production and consumption patterns in the face of higher costs but also invest in more energy-efficient equipment. For instance, households not only travel less due to the higher cost of petroleum products but also buy more efficient cars. Below, we show that, if this assumption does not hold, the observed macroeconomic and sectoral impacts will be much less positive.

Finally, we assumed that the required investments are accumulated within both policy scenarios and that the carbon taxes serve as a source for these investments, significantly increasing the saving rate within the economy. In reality, this might not necessarily be the case, and money collected from the carbon taxes might be transferred to the government budget (to increase expenditures) or to households. We explored these cases further and show that these possible options pose significant risks for the long-term macroeconomic growth.

Impact of the Carbon Export Permits

Within this scenario, we assumed that the Ukrainian gas sector exports 10 Mt of CO_2 from the entire carbon budget of Ukraine at the price of 20 euros/ton CO_2-eq. The revenue from this carbon permit sale is invested in the gas extraction sector over the 2025–2027 time frame. These investments are leveraged by a factor of five, which results in total additional investments in the gas sector of 1 bln euros over the 2025–2027 period. We also assumed that these investments additionally increase the energy efficiency of the gas extraction sector by 1% per year starting in 2028.

Our results show that there is no significant impact of limited carbon export permits. Essentially, changes in the real GDP and households' income stay at the same level as in policy option "a", with strong positive trends. There are some minor changes at the sectoral level; in particular, somewhat higher growth rates are observed for the gas sector in Scenario 2, but the difference is around 1% in 2050.

The Role of Energy Efficiency Improvements

The results suggest that the additional energy efficiency improvements implemented in Scenarios 2 and 3 (policy options "a" and "b") play a key role in boosting GDP growth and real households' income. If these improvements are excluded from consideration, which is a conventional approach in most CGE-based economic assessments, there will be limited benefits in terms of additional GDP growth (Figure 2.11). This is especially true for Scenario 3, with much greater energy efficiency improvements than Scenario 2. **By comparing policy options "a" and "c", we can see that, in 2050, the cumulative energy efficiency improvements contribute more than half of the additional GDP growth (Figure 2.11).**

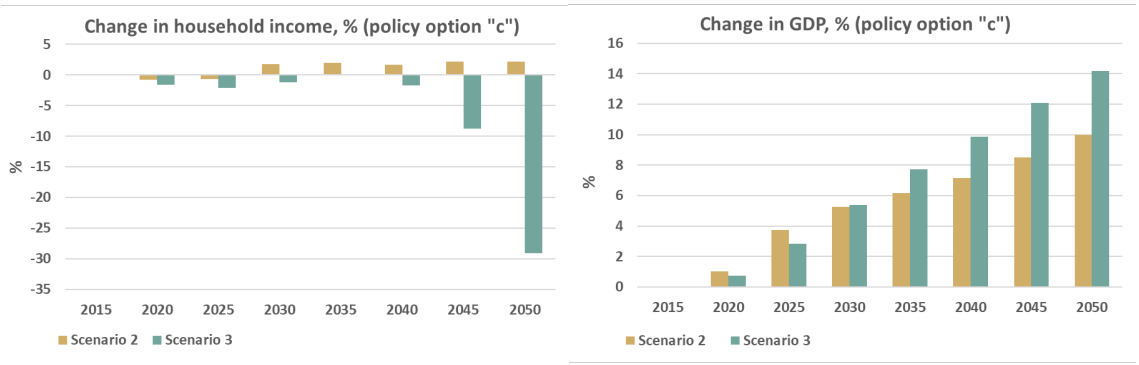


Figure 2.11. Change in the GDP and income under policy option "c": no energy efficiency improvements

Even more important is the role of energy efficiency improvements in ensuring households' income growth in Scenario 3 (Figure 2.11). Without accounting for these changes, the results suggest that households' real income could decrease in the long run relative to the baseline case (Scenario 1). If energy efficiency improvements are not implemented in Scenario 2, households' real income will remain almost the same as in the baseline scenario, with a minor increase in 2050. **Energy-intensive sectors will experience larger output reductions if no energy efficiency changes are incorporated, and the same holds for the sectors that supply, transform and process fossil fuels.**

Alternative Cases of the Carbon Tax Income Reallocation

Apart from reinvestment of the collected carbon tax income, different reallocation measures could be considered. In this subsection, we explore two such options – reallocation of the collected tax income to the government (option "d") and to households (option "e"). In both cases, our estimates suggest that the reallocation would have negative macroeconomic and sectoral implications, with option "e" (reallocation to households) being slightly more attractive (Figure 2.12).

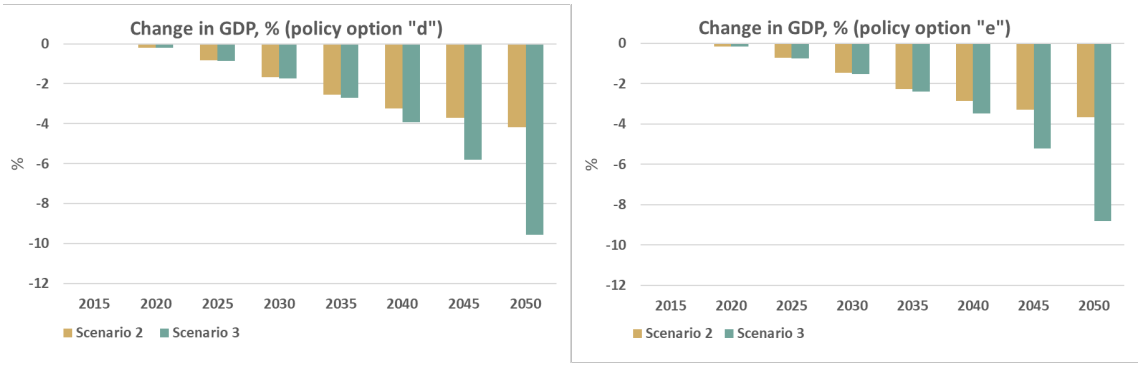


Figure 2.12. Change in the GDP under policy options "d" and "e": all carbon tax revenue stays with the government ("d") or is reallocated to households ("e")

At the same time, Scenario 3 results in much lower reductions in GDP growth rates relative to the baseline than Scenario 2. In particular, a 3.5%–4% GDP reduction in 2050 for both reallocation policy options in Scenario 2 is equivalent to a slowdown in the annual GDP growth rate of around 0.1%. In the case of Scenario 3, the corresponding slowdown is less than 0.3%. At the same time, we should take into account the very ambitious mitigation target in Scenario 3 (an 87% reduction in emissions in 2050 relative to the baseline) and, considering the large co-benefits from GHG emission reductions, these should not be viewed as a high abatement cost.

Co-benefits from Emission Reductions

Numerous studies have estimated that **stringent climate mitigation policies are associated with significant co-benefits**, including reductions in local air pollution and energy security improvement. Co-benefits can be also estimated from reductions in GHG emissions.

To monetize the damage (benefits) from changes in CO_2 emissions, the notion of the social cost of carbon (SCC) has been widely applied in the literature. The SCC represents the average global damage resulting from 1 ton of CO_2 emissions. We used a central value of 35 US dollars/ton CO_2. We assumed that the SCC value grows by 3% annually. Following evidence from

a SCC meta-analysis and a review of other studies, we used a lower bound of 15 US dollars/ton CO_2 and an upper bound of 55 US dollars/ton CO_2.

Our results suggest that, in the case of Scenario 2, in 2050, the monetized benefits from carbon emission reduction, following the application of the SCC values, would be between 9.2 bln and 33.6 bln US dollars, with a central value of 21.4 bln US dollars. **In the case of Scenario 3, larger emission reductions would result in a much larger gain – between 17.1 bln and 62.9 bln US dollars in 2050.**

Several studies have shown that **high levels of outdoor air pollution could result in significant economic losses** due to the increased mortality, morbidity and productivity. The IMF's (2015) study[25] estimated that, in Ukraine, the cost of outdoor air pollution was around 68 billion US dollars in 2014. Pollution from coal combustion is the main contributor to this number (accounting for over 97% of these costs). In the reference case (Scenario 1), the primary supply of coal increases over time, leading to a higher level of pollution, assuming that no major changes occur in emission factors. In the case of Scenario 2, the coal primary energy supply is over 51% lower than in the reference case, already bringing significant health benefits through reductions in pollution levels. Even more benefits from the air quality improvements should be expected in Scenario 3, in which coal use is almost eliminated by 2050. Even assuming that the cost of outdoor air pollution in Ukraine does not change over time (relative to the 2014 levels), Scenario 3 will produce additional benefits of around 68 bln US dollars in 2050 relative to the reference case and over half of this number (around 34 bln US dollars) relative to Scenario 2.

2.6 IMPLICATIONS OF THE EU BORDER CARBON ADJUSTMENT TAX

While there is still considerable uncertainty regarding the possible design of the EU Carbon Border Adjustment Mechanism (CBAM), in Report 4A, we provided an assessment of the possible implications of this policy measure for Ukraine. In this section, we present an overview of the corresponding findings and consider how these results correspond to the currently discussed CBAM set-up. For a detailed discussion of the methodological approach and data inputs, interested readers are referred to Report 4A.

For the assessment, we assumed that the EU27 imposes border carbon adjustment (BCA) on imports from all countries and regions, including Ukraine. The tax is imposed in the form of the ad valorem equivalent on imports of commodities that belong to the EU ETS sectors. To calculate the corresponding tax rate, the average ETS tax for 2019 was estimated and then converted into 2014 US dollars. Thus, the tax rate is 26 US dollars/t CO_2-eq. The equivalent import tax was estimated based on the emissions embodied in exports. We considered two options for the carbon content:

- based on the emission intensity of the exporting country;
- based on the emission intensity of the EU27.

Depending on whether Ukraine's or the EU's content is used to estimate the ad valorem equivalent, the corresponding import taxes vary significantly (Figure 2.13). For instance, in the case of ferrous metals, with Ukraine's carbon intensity, the BCA tax is estimated to be 6.6%, while, with the EU carbon content, the tax is 0.7% – more than nine times lower. It should be noted that, in the current assessment, we considered Scope 1 + Scope 2 + Scope 3 emissions.

[25] International Monetary Fund (IMF). 2015. Energy Subsidies Template. http://www.imf.org/external/np/fad/subsidies/

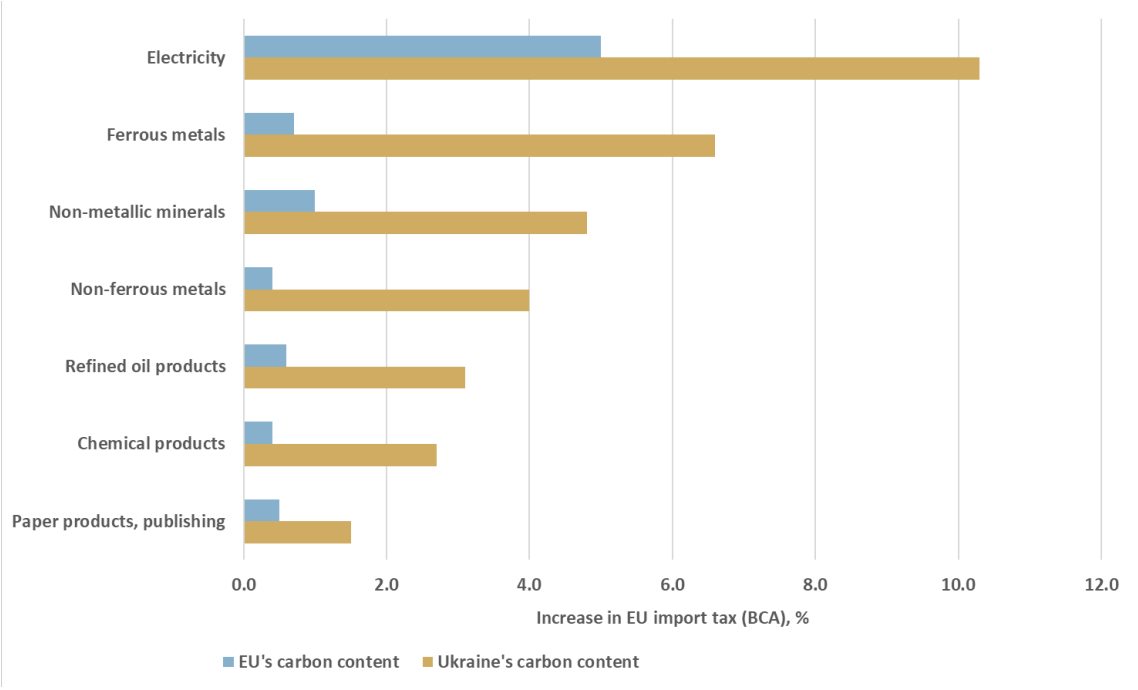


Figure 2.13. Ad valorem equivalents of the BCA tax under the EU's and Ukraine carbon content assumptions

In terms of the macro implications of the BCA, the estimates suggest that there are no significant negative impacts as, even under Ukraine's carbon intensity assumption, the GDP falls by less than 0.1% while welfare reduces by 450 mln US dollars. Much smaller impacts are observed under the EU's carbon content assumption, as Ukraine's GDP barely changes.

The aggregate output reduces by around -0.002% in both carbon intensity cases. At the sectoral level, ferrous metals suffer the most, with the output volume reduction reaching almost 4% in the case of Ukraine's carbon content; this falls to only a 0.3% reduction under the EU's carbon intensity assumption (Figure 2.14). Refined oil production and electricity are two other sectors that suffer in terms of output, behind the ferrous metals. At the same time, the reduction in output in these sectors exposed to energy intensity and trade is almost fully compensated by the increasing output in some other manufacturing activities that do not face the BCA tax, such as motor vehicles, other machinery and other manufacturing. The magnitude of impacts is on average 5–6 times lower in the EU's carbon content case than under the Ukraine's carbon intensity assumption.

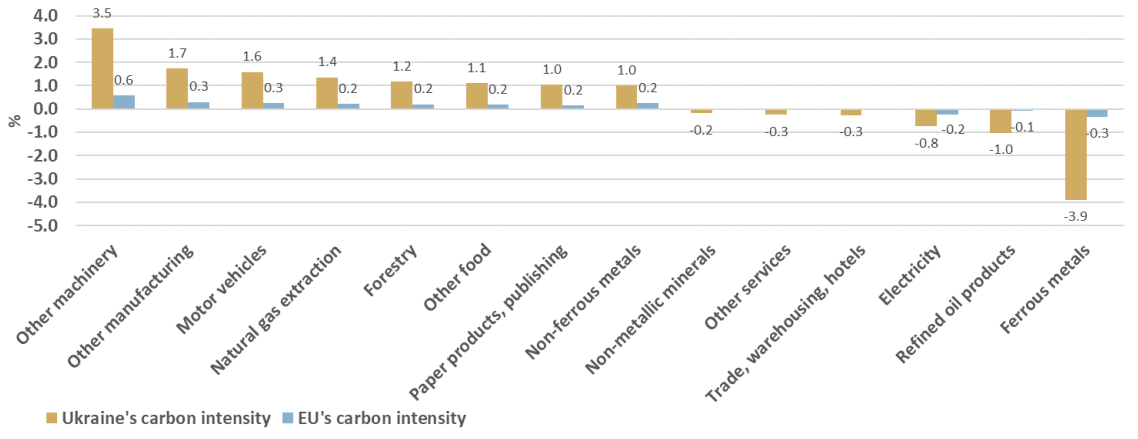


Figure 2.14. Changes in Ukraine's sectoral output due to the EU's BCA tax imposition

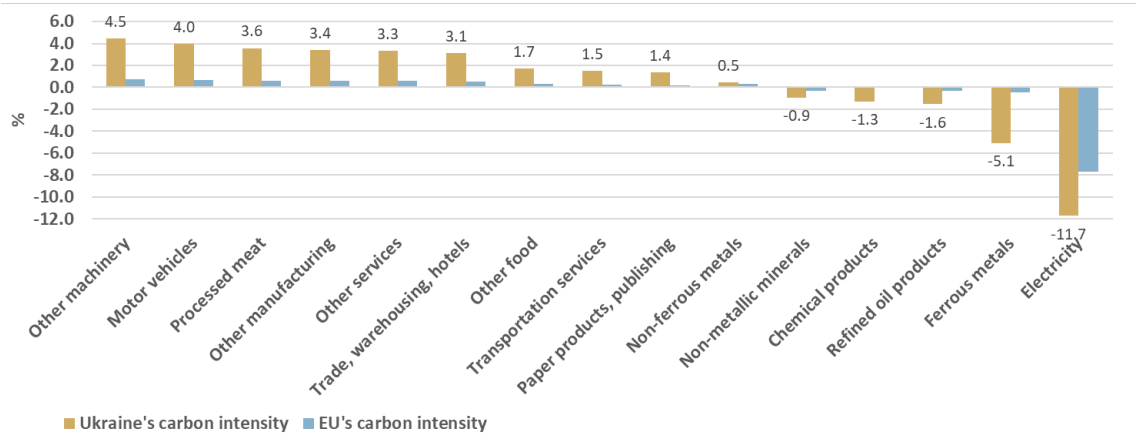


Figure 2.15. Changes in Ukraine's exports due to the EU's BCA tax imposition

On the trade side, electricity, ferrous metals, refined oil products and chemical products suffer the most (Figure 2.15). In addition, while exports fall by almost 12% in the case of electricity (in Ukraine's carbon content case), this does not significantly affect electricity producers as the share of electricity exports in the total output is relatively small. Ferrous metals, on the contrary, constitute a major category of Ukraine's exports, with potential for significant adverse impacts on domestic producers.

However, while the exports of ferrous metals to the EU indeed suffer substantially, with a reduction of 25.8% in the case of Ukraine's carbon content, a significant redirection of ferrous metal exports is observed (Figure 2.16). Depending on the trading partner, exports of ferrous metals increase by 2.2%–4.4%. As a result, in the case of Ukraine's carbon intensity, around 29% of exports lost to the EU is reallocated to other destinations, meaning that, while ferrous metal exports to the EU fall by around 1020 mln US dollars, exports to other regions increase by 296 mln US dollars. The reallocation share is even larger in the case of the EU's carbon intensity, in which it reaches 42%. The impacts on export volumes are much smaller in the EU's carbon intensity case (than under the Ukraine's carbon content assumption) as Ukraine's aggregate ferrous metal exports fall by only 0.5%, with a reduction in exports to the EU of around 2.9%.

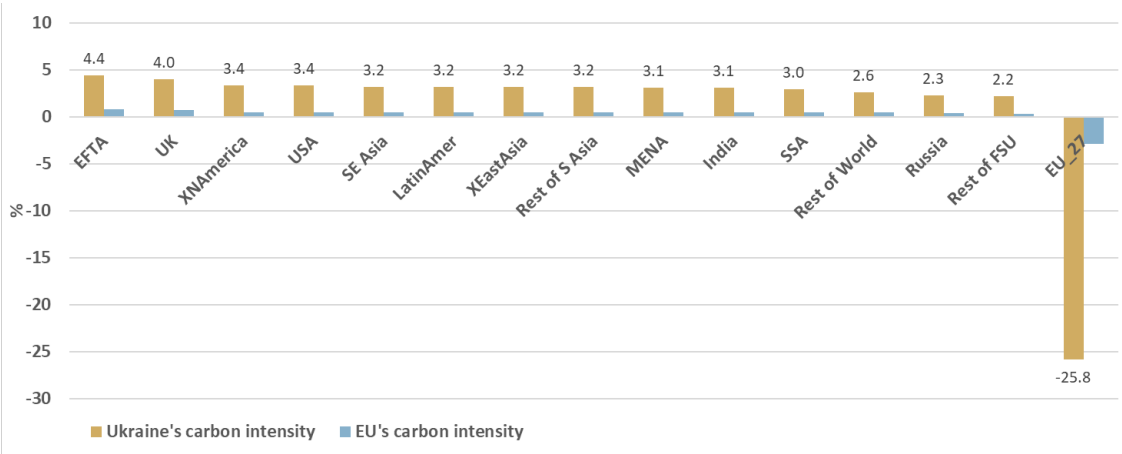


Figure 2.16. Changes in Ukraine's exports of ferrous metals by destination due to the EU's BCA tax imposition

The simulations suggest that the *imposition of the 26 US dollars/t CO_2 BCA tax does not have any major negative impact on the Ukrainian economy* as the reduction in the GDP is between -0.07% and -0.01%, while welfare falls by between -451 mln and -74 mln US dollars, depending on the carbon content assumption. ***These results, though, vary significantly depending on whether the EU's or Ukraine's carbon intensity is considered*** **to determine the BCA rate.** As the EU's carbon intensity is on average 5–6 times lower than that of Ukraine, the negative impacts are also much smaller in the former case. ***The iron and steel sector*** **is associated with 80% of all CO_2 emissions exported from Ukraine to the EU (in the ETS sectors) and *suffers the most* from the BCA tax.** At the same time, as other non-EU countries also face BCA, there is a *redirection of exports* from the EU to these other destinations, which *reduces the potential export losses*. The aggregate iron and steel exports from Ukraine fall by between -5.1% and -0.5%, while the exports to the EU fall by between -2.9% and -25.8%.

There are several caveats in our analysis that should be highlighted. *First*, in our assessment, we used Scope 1 + Scope 2 + Scope 3 emissions, while the currently discussed EU CBAM would cover Scope 1 emissions only.[26] *Second*, in our analysis, we did not account for non-combustion CO_2 emissions from industrial processes (e.g. cement production). *Third*, we assumed a specific carbon price within our assessment (based on the EU ETS 2019 level). A different carbon price would change the results, though one can anticipate that the magnitude of the impacts would be roughly proportional to the reported ones. *Fourth*, while the border carbon adjustment in our analysis is imposed on all manufactured commodities, in the recently announced EU CBAM proposal, only selected commodities are targeted, such as aluminium, iron and steel, cement, fertilizers and electricity. *Finally*, in the current assessment, we assumed that imports to the EU would face the full CBAM rate; that is, the share of free allocations would be "0". In the recently announced EU CBAM proposal, free allocations will gradually be reduced over the 2025–2035 period.

While the CBAM policy results presented in this study are of a stylized nature and do not correspond precisely to the set-up proposed by the European Commission, our findings are qualitatively similar to those of other studies. For instance, Kuusi et al. (2020)[27] estimated that the CBAM implementation might reduce the GDP in the Eastern European countries (excluding Russia) by around 0.03%. The recent UNCTAD (2021) report[28] found that, with a carbon price of 44 US dollars (almost 70% higher than the price considered in this study), the Ukrainian output of iron and steel would reduce by 2.9%–5.7% (depending on the scenario), while the per capita GDP would decline by 0.2%–0.5%.

[26] European Commission (EC). 2021. Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism. Brussels, 14 July 2021. https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf

[27] Kuusi, T., Björklund, M., Kaitila, V., Kokko, K., Lehmus, M., Mechling, M. and Wang, M. 2020. Carbon Border Adjustment Mechanisms and Their Economic Impact on Finland and the EU. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162510/VNTEAS_2020_48.pdf

[28] United Nations Conference on Trade and Development (UNCTAD). 2021. A European Union Carbon Border Adjustment Mechanism: Implications for Developing Countries. https://unctad.org/system/files/official-document/osginf2021d2_en.pdf

SECTION 3. UKRAINE'S UPDATED NDC IMPLEMENTATION POLICIES AND MEASURES

To achieve the NDC target in the proposed combined sensitivity scenario, the project developed a comprehensive list of sectoral policies and measures that are recommended for implementation by the GoU under the national NDC implementation plan. The proposed policies and measures were presented and discussed during the broad stakeholder consultation process. Throughout this process, ministries, legislators, state agencies and local authorities, industry associations and civil society, academia and experts provided comments on the proposed list of sectoral policies and measures. MinEcology, as the leading ministry for climate policies, has also conducted informal bilateral discussions and consultations with representatives of various private business groups to report the NDC target process and to enhance the understanding and buy-in among private businesses. Combined sensitivity scenario policies and measures have been developed for both mitigation and adaptation targets.

What we present here is therefore not an exhaustive list but a prioritized set of policies and measures, both by sector and cross-cutting, that not only reflect the current state of play and are practical but are also comprehensive, taking into consideration the social behavioural changes necessary for a sustainable economic transition to occur though NDC implementation.

The proposed policies and measures could reveal **overall GHG emission reduction potential (in the combined sensitivity scenario) of around 1 037,5 million tons of CO_2 equivalent cumulatively during the period 2021–2030**. Additional potential multiplying effects of cross-cutting policies and measures during the NDC implementation period were not estimated for the purpose of this report.

3.1. MITIGATION POLICIES AND MEASURES

Electricity Sector

Decarbonizing the electric power sector of Ukraine is one of the key elements and challenges of decarbonizing Ukraine's economy. The policies and measures in this sector aim to increase the share of renewable energy sources, ensure proper functioning of the national electricity market, introduce RAB tariffs and introduce and promote the smart grid and distributed energy principles, including smart metering and integration into the EU power market. The construction of energy storage facilities is also proposed as one of the key measures here.

- Ensure the proper functioning of all the segments of the electricity market;
- Provide cost-reflective market prices for electricity for consumers;
- Introduce RAB tariffs for electricity transmission and distribution system operators;
- Introduce smart solutions and demand-side management in electricity;
- Integration with the EU's electricity markets;
- Implement the National Emission Reduction Plan (NERP) for large combustion plants;
- Expand energy storage;
- Create competition in RE deployment (renewable energy auctioning process);
- Ensure that green electricity producers are active and responsible market participants.

Heating Sector

The heating sector is important for Ukraine as its geographic and climatic zone requires the use of the district heating system for over 6 months a year and the heating infrastructure is mostly old and very inefficient. The decarbonization policies and measures propose to incentivize the use of renewable energy in the district heating sector and promote decentralized and individual heating systems as a measure to reduce or avoid heating distribution losses and make the district heating system more efficient and less carbon intensive.

- Introduce incentive mechanisms for renewable energy and high-efficiency cogeneration deployment in district heating;
- Promote individual alternative heating systems.

Fuel Production, Transportation and Distribution

The fuel (crude oil, natural gas and coal) production, transportation and distribution sector policies and measures aim to reduce technological losses and improve extraction, transportation and distribution technologies, including natural gas storage facility improvements and incentives to apply the best available technologies during the extraction process.

- Prevent methane emissions during the production of natural gas, crude oil and coal in existing coal mines;
- Reduce methane emissions during oil and natural gas transportation;
- Upgrade underground natural gas storage facilities to comply with the existing mandatory standards and technical requirements;
- Introduce incentives to use the geothermal energy of depleted oil and gas wells;
- Introduce conservation technologies to reduce the GHG emissions from old oil wells, natural gas fields and closed coal mines;
- Deploy hydrogen.

Industry Sector

Industry decarbonization policies and measures aimed to introduce energy audits, an energy management system, ESCO contracting and the establishment of energy efficiency incentives for industrial companies while enabling access for EU research and development activities. All the proposed policies and measures should put Ukrainian industry on an economic transformation pathway leading to decarbonization.

- Energy audits and energy management systems for industrial companies;
- Service contracting and additional consultancy for industrial companies;
- Stimulation of/incentives to adopt energy efficient measures for industrial enterprises;
- Access to EU R&D activities for Ukrainian industrial companies;
- Hydrogen technologies for industry.

Transport Sector

The policies and measures for the transport sector aim to improve the transport infrastructure, including inter-modality, on the national, regional and municipal levels, improve the quality of public

transportation and thus increase the number of people choosing it to travel, incentivize the purchase and use of efficient and electric vehicles, improve the quality of roads, electrify the railways and introduce hydrogen as a new fuel for vehicles. All the proposed policies and measures will also lead to improved air quality in cities, a better traffic situation and transport security. The introduction of separate renewable energy targets for the transport sector is also recommended.

- Introduce CO_2 emission performance standards;
- Improve the quality of highways;
- Improved transportation infrastructure;
- Optimize the structure of passenger and freight traffic in cities;
- Support for public transport fleet renovation;
- Incentives and stimulation measures for electric vehicles;
- Fiscal incentives for private transport fleet renovation;
- Electrification of road transport;
- Hydrogen technologies for transport;
- Approximation of the directive on roadworthiness tests for motor vehicles and their trailers;
- Renewable energy target in the transport sector.

Buildings/Housing Sector

The buildings/housing sector is an important sector for Ukraine; therefore, the policies and measures proposed in this sector aim to improve the institutional capacities of the recently established Energy Efficiency Fund, introducing recent EU building standards and requirements while establishing relevant financial mechanisms for improving the energy efficiency of public buildings, private buildings and housing, and commercial buildings. A smart metering system for all utilities is another set of complex policies that ought to be introduced gradually throughout the utility supply system.

- Empowering the Energy Efficiency Fund;
- Energy performance and energy certification of buildings;
- An energy management and information system for public buildings;
- Energy efficiency investment programmes for public buildings;
- Promotion of heat and hot water metering and consumption-based billing.

Agriculture and Forestry

The agriculture and forestry policies and measures aim to introduce smart agriculture and forestry principles and promote the application of the best technologies available in crop and livestock production as well as enhancing sustainable forest management practices. The development and adoption of the framework national agricultural strategy will enable and incentivize smart agriculture technologies, such as wider application of telecommunications, no tillage, smart and controlled fertilizer use and the development of organic and local production. Empowering the forestry sector through afforestation and forest protection is a crucial policy for GHG emission removals.

- Develop an agricultural strategy;
- Promote conservation tillage technologies;
- Promote the use of information and telecommunication technologies in crop production;
- Promote the use of slow- or controlled-release fertilizer forms;
- Promote organic crop production;
- Reduce the GHG emissions from livestock;
- Afforestation;
- Develop a land allocation mechanism.

Waste Sector

The waste sector policies and measures will introduce the best international practices into the waste management hierarchy in Ukraine while ensuring the development of a centralized waste collection system throughout the country and putting Ukraine on the track towards circular economy principles. The municipal solid waste and sludge/wastewater treatment technologies in Ukraine are out of date; therefore, the application of the best technologies available is essential for the sustainable development of the waste sector in Ukraine. Another set of policies in municipal waste management involves the stimulation of waste use and its utilization as an alternative fuel in other industries, such as cement and others, and the recovery of valuable energy sources, like electricity and biogas production, fertilizer production and others. Municipal waste prevention policies that limit the amount of waste reaching landfills are also important in this sector, which is expected to grow in the medium term.

- Prevent MSW disposal;
- Stimulate electricity production from landfill biogas;
- Stimulate landfill gas flaring at MSW landfills;
- Stimulate methane energy recovery from wastewater treatment;
- Promote the denitrification of wastewater and sludge;
- Produce alternative fuel from MSW with the purpose of decreasing the fossil fuel needs in the cement industry.

Bioenergy

These policies and measures aim to foster the development of the bioenergy sector in Ukraine as one of the major drivers of Ukraine's green growth and circular economy transition. On one hand, the bioenergy sector will further unfold, in a sustainable way, the huge energy potential of agrarian and wood biomass, biofuels, biogas/biomethane and energy crops. On the other hand, it will contribute to effective biowaste management practices and the improvement of the soil quality and its carbon sequestration capacity. Finally, the sector will be able to create significant social and economic merits, generating green jobs, mainly in rural areas, as well as fostering organic agriculture practices.

- Bioenergy road map and action plan development;
- Sustainability criteria for biomass;
- Biomass-based heat and CHP generation;

- Creation of biomass burse;
- Biogas/biomethane supply and demand;
- Energy crops;
- Biofuel blending mandate.

Fiscal and Market Mechanisms

Based on the best international practices and recent approaches to sustainable, green and climate finance – as MDBs, IFIs and other financial organizations have outlined and analysed in various reports (Global Landscape of Climate Finance 2019; Joint MDBs Climate Finance Report 2019) – the overall objectives of fiscal and financial policies and measures are to build the institutional capacity of Ukraine's financial and banking system to scale up green and climate finance, including finance from public and private sources, enabling various innovative green and climate-friendly fiscal and financial instruments (e.g. green bonds, blended finance instruments such as grants, bonds, sustainable finance, green taxonomy, equity, guarantees, investment loans, line of credits, sustainable investment, etc.) following a general stakeholder consultation in the formal governmental concurrence process.

- Green bonds;
- Climate finance institutional framework;
- Climate finance instruments (grants, bonds, equity, guarantees, investment loans, lines of credit and sustainable investment);
- Green procurement;
- Green taxonomy (taxation system greening);
- Establishment of a national GHG emission cap-and-trade scheme (GHG emission trading scheme).

Society Covenant

The policies and measures under the Society Covenant aim to introduce, promote and advocate new, more responsible, smarter, sustainable and climate-friendly behaviour patterns among citizens, companies and organizations. The enhanced role of private business, communities and civil society organizations under this group of policies and measures is expected to be empowered by proper established and operationalized financial and other incentives on the municipal and national levels. The promotion of responsible consumption of resources and food and legally recognized remote modes of work and the development of smart mobility networks are among the recommended policies and measures.

- Introduce energy labelling and eco-design regulations;
- Develop smart mobility;
- Introduce remote working practices;
- Promote a more sustainable diet and nutrition;
- Encourage responsible consumption;
- Engage in awareness raising, outreach and education.

3.2. ADAPTATION POLICIES AND MEASURES

Adaptation is one of the key components of the long-term global and country-specific response to climate change. By 2030, Ukraine plans to establish a robust national framework for adaptation to climate change to enhance its adaptive capacity, strengthen its resilience and reduce its vulnerability to climate change, as provided for in Article 7 of the Paris Agreement.

Adaptation policies and measures have been discussed and presented to MinEcology, and, to a large extent, its key elements have been incorporated into the draft National Framework Adaptation Strategy developed by MinEcology as a separate policy document.

Regulatory and Institutional Adaptation Policies and Measures:

- Develop and adopt the Adaptation Strategy of Ukraine until 2030;
- Develop, adopt and implement the Adaptation Action Plan by 2030;
- Strengthen the cooperation on enhancing adaptation actions;
- Assess the continuous progress in adaptation actions and reporting under the Paris Agreement.

Agriculture

- Establish the Climate Change Advisory and Coordination Body in Agriculture, including regional offices;
- Enhance the scientific support for tackling climate change in the crop production, livestock, forestry, fishery and hunting sectors;
- Raise awareness and provide education and professional education enhancement of adaptation to climate change in agriculture;
- Build the capacity for adaptation to climate change for local communities and households in rural areas;
- Stimulate agricultural producers to implement climate change adaptation measures in the following sub-sectors:
  - Crop production;
  - Livestock;
  - Fishery and aquaculture;
  - Hunting.

Forestry

- Improve forestry legislation to reflect the adaptation to climate change;
- Increase scientific support for forestry regarding climate change;
- Raise awareness of and improve education and professional education about adaptation to climate change;
- Increase the capacity to adapt to climate change in the forestry sector;
- Incentivize production companies and institutions to improve climate change adaptation measures.

Water management system

- Develop and adopt river basin management plans for nine river basin districts in Ukraine in accordance with the national legislation and in line with the EU Water Framework Directive;
- Implement the new national monitoring programme in accordance with the Decree of the Cabinet of Ministries on the Approval of the Order on State Water Monitoring[29];
- Develop and update the water use balance for the main Ukrainian river basin districts in accordance with Articles 134 and 15 of the Water Code[30] and the Decree of the Ministry of Energy and Environmental Protection[31];
- Develop bilateral and multilateral transboundary cooperation with neighbouring states to support the integrated management of transboundary water resources and to share experience and knowledge to ensure improved resilience, reduced risks of water-related disasters and better adaptation of transboundary basins to climate change;
- Implement the EU Flood Directive in Ukraine;
- Reconstruct the water supply and wastewater treatment systems, contributing to the adaptive capacity of the country[32];
- Update the vulnerability assessment for the water sector and subsequently improve the corresponding adaptation plans and measures;
- Establish and operate river basin councils to ensure the engagement of stakeholders and the integration of different sectoral needs into the development and implementation of river basin management plans under climate change (in accordance with Article 133 of the Water Code[33]).
- Strengthen the adaptation potential of biosphere reserves through capacity building, awareness raising and the implementation of concrete ecosystem-based adaptation measures.

Health protection from climate change

- Conduct comprehensive research on health vulnerability to climate change and detailed risk assessments;
- Improve the existing national health plans on climate-sensitive diseases, taking into account the outcome of the health vulnerability/risk assessment;
- Revise the existing operating procedures within the public health system to respond to climate risks;
- Strengthen the human resource capacity via educational curricula and professional training of health personnel to ensure a sufficient number of health workers to deal with the health risks associated with climate change;
- Establish an early warning system for climate health risks.

[29] https://zakon.rada.gov.ua/laws/show/758-2018-%D0%BF/conv
[30] https://zakon.rada.gov.ua/laws/show/213/95-%D0%B2%D1%80#n946
[31] https://zakon.rada.gov.ua/laws/show/z0232-17
[32] https://www.nefco.org/procurements/general-procurement-notice-nip-ukraine-water-modernisation-programme/
[33] https://zakon.rada.gov.ua/laws/show/213/95-%D0%B2%D1%80#n946;
https://zakon.rada.gov.ua/laws/show/z0231-17

Energy sector

- Should Ukraine opt for build new nuclear power plants, the latter should be located in the areas of not only high demand for electricity, but also taking into account cites with the expected lower growing average temperature, and less prone to flooding;
- In areas where water availability for cooling (including higher water temperatures, blooming algae) is already compromised, generation has to be curtailed, or reserve cooling systems should be designed (e.g., dry cooling towers);
- Electricity transmission infrastructure should undergo rigorous and regular maintenance and renovation. High-speed winds directly threaten the transmission and distribution lines, inducing their breaking, and carrying more dust and dirt. All these factors may lead to power disruptions;
- Locate energy generating facilities far from the forest and other objects that may suffer from forest fires and wildfires. Use numerous plowed strips if the citing of the existing energy generating facility is located close to the woods;
- Increase preparedness for maintenance of natural gas and oil products transmitting pipelines, including that for spills, which extreme weather events might cause, material damage caused by very high and very low temperatures, and rapid fluctuations;
- In the areas with the projected sea-level rise, infrastructure adjustments need to be made (dams, dykes) with gradual relocation of the existing plants or building new plants, including using contemporary energy technologies;
- Consider the current and expected climate change (e.g., change in the precipitation patterns, runoff reduction, mean temperature, water availability, rivers shallowing) when building new hydropower plants. If possible, deeper water reservoirs with smaller water surface area should be preferred (due to enhanced evaporation caused by higher mean temperatures and higher wind speeds);
- Ukraine is a water-scarce country; thus, a potential water demand competition with other industries should be considered (e.g., water for irrigation purposes in agriculture).
- Depending on the availability of funds, the following activities are planned:
  - Conduct comprehensive research on the vulnerability of the fuel and energy system to climate change and perform a detailed risk assessment;
  - Develop policies and measures based on the results of a vulnerability/risk assessment and best European practices;
  - Incorporate science-based policies and measures into the existing plans and programmes related to the fuel and energy system.

Municipal sector

- District heating/electricity: adapt buildings by using up-to-date technologies and materials and electricity and heating network upgrades to meet changed heating/cooling demands.
- Solid waste management: elimination of uncontrolled disposal, which promotes pathogen and disease vectors in hotter temperatures.
- Resilient water supply: introduction of water-efficient technologies and network upgrades to combat water stress, diversification of water sources, improvement of water

storage, network upgrades/leak reduction and the introduction of risk management measures related to droughts and floods.

- Green infrastructure: encourage urban forestry, urban and peri-urban agriculture and the adaption of land use towards greening through regulation and planning.

Transport

- Construct new transport infrastructure on high land plots (due to floods and the expected sea-level rise);
- Timely warning of passengers about extreme weather events;
- Develop insurance programmes that will include unfavourable weather events;
- Fight wildfires (which is especially important for railways);
- Ensure proper quality of road surfaces with timely removal of snow;
- Reconstruct water sewage systems to ensure efficient and fast water intake in the case of heavy precipitation;
- In railways, continuously checking the integrity of trains and carriages with different measures, including ultrasound, together with efficient maintenance of rail beds, is essential;
- In water transport, ensure the necessary depth of waterways in the long run;
- In air transport, refurbish take-off strips with ice-proof elements.

SECTION 4. UKRAINE'S UPDATED NDC CLIMATE FINANCE

4.1 OVERVIEW

The transition to a low-carbon, climate-resilient Ukraine over the next decades requires an unprecedented redirection of economic activity, which will only be achieved if the necessary investments can be mobilized from public and private sources of finance. Based on the scenarios presented in the previous section, it is possible to estimate the financing gap that needs to be addressed – in addition to delivering the business-as-usual (BAU) climate-related investment volumes – to achieve Ukraine's climate and energy targets for 2030 and 2050 in the combined sensitivity scenario.

Normally, "climate finance" refers to the investments made to fund the transition to a low-carbon global economy that will enable both climate change mitigation and adaptation investments and build resilience to the impacts of a changing climate. In line with this, the principles of the UNFCCC suggest that developed countries should mobilize "new and additional" financial resources to meet the "incremental costs" of climate change. The challenge of the international community has been to ground these principles in a practical interpretation and definition that can be broadly applied. Instead, the push for building practical definitions, anchored in investment flows, has largely come from multilateral development banks (MDBs) and international research organizations.

For the purpose of this study, the definition of climate finance was taken from the Common Principles for Climate Mitigation Finance Tracking[34] proposed by the leading MDBs. To derive projections of the mix of financing sources needed over the 2021–2030 period, the capital investments in Ukraine for 2010–2019, as reported by the State Statistics Service, were evaluated.[35] Within this time frame, capital investments were mobilized through state budgets (4%), local budgets (5%), enterprises' and organizations' own funds (66%), bank loans and other loans (11%), foreign investors' funds (2%), public funds for housing (8%) and other financing sources (3%). As such, state and local public budgets have historically been responsible for financing around 9% of capital investments, with the remainder of the financing being delivered by private or mixed sources of financing. It was assumed that a share of enterprises' and organizations' own funds recorded in the national statistics include flows from state-owned enterprises,[36] which may be owned fully or partly by the government. Including a share[37] of the own enterprise funds as public capital (but not channelled through state or local budgets), the average share of public finance was estimated at around 40%, with 60% being delivered by private sources. Regardless, the derived shares coincide very closely with the public to private sector ratio reported by the Climate Policy Initiative for the Eastern European region, which stood at 38% for public and 62% for private finance in the latest available reporting period (2017/2018).[38]

[34] MDBs. 2015. Common Principles for Climate Mitigation Finance Tracking. https://bit.ly/2ZgDxnw
[35] Government of Ukraine. 2019. State Statistics Service. Capital Investment for 2010–2019, by Financing Sources. http://ukrstat.gov.ua/operativ/operativ2007/ibd/iokjf/iokjf_e10-13_bez.htm
[36] There are about 3,500 registered state-owned entities in Ukraine. https://bit.ly/3dT8m8J
[37] We made assumptions on the share of public versus private financing across the category "own funds of enterprises and organizations" (30:70), "bank loans and other lending" (0:100) and "other financing sources" (50:50).
[38] CPI. 2019. Global Landscape of Climate Finance 2019. 2017–2018 GLCF Central Asia & Eastern Europe Data. https://bit.ly/3pu6QgW

Recognizing that such a financing mix relates to a range of activities funded across economic sectors, the public to private finance shares were adjusted for each of the sectors in line with the combined sensitivity scenario modelling results. The rationale for this approach comes from the recognition that, given the different characteristics of the underlying business models, the levels of profitability and the payback periods, the willingness of the private sector to invest differs considerably. Aggregate investment data for specific sectors were used as well as historical climate finance data to provide a reasonable estimate of the financial capacities of both public and private sources of finance to shoulder the forecasted costs.[39] Using those estimated shares, the mix of financing sources over the 2021–2030 period was adapted to present a projection of how the corresponding financing needs could be distributed across these different channels.

4.2 FORECASTING FINANCIAL FLOWS

The modelling results for the combined sensitivity scenario highlight that capital investments will not only need to be scaled up but will also have to be redirected into technologies and measures that are compatible with a long-term, low-carbon development pathway. These changes require investments in, among others, the following areas:

- A further increase in the renewable energy installed capacity;
- Early adoption of new technologies, e.g. hydrogen and CCS;
- Significantly more energy-efficient buildings;
- Increased electrification of transport;
- Increased organic crop production and reduction of methane in agriculture;
- Increased carbon sink through afforestation;
- Better waste management and water use.

Financing Mix for Total Capital Investments

The modelling results for the combined sensitivity scenario (see Table 2.5) indicate that its implementation requires the attraction of on average around 26 billion euros annually up to 2030. As this is estimated to represent 70–80% of all capital investments, the average capital investment over the 2021–2030 period is expected to be at least 33 billion euros annually. Given that capital investments in Ukraine totalled around 20 billion euros in 2019, this represents a 65% increase against the 2019 data for the average investment year.

As such, **the total capital investments required for the Ukrainian economy's transition to a low-carbon development pathway are reasonable in absolute terms, considering the historical trends**. Furthermore, these results underpin the notion that the capital investments modelled in the BAU scenario build on historical investment trends; for example, the assumed total capital investments in the BAU scenario amount to around 24 billion euros in 2021 and 2022, which is a reasonable extrapolation of the historical investment volumes, as depicted in Figure 4.1. The challenge is rather to redirect the existing financial flows into greener investments that are compatible with a climate neutrality pathway for Ukraine.

[39] Other data sources were consulted, including the catalogue of OECD databases and data indicators maintained by the World Bank.

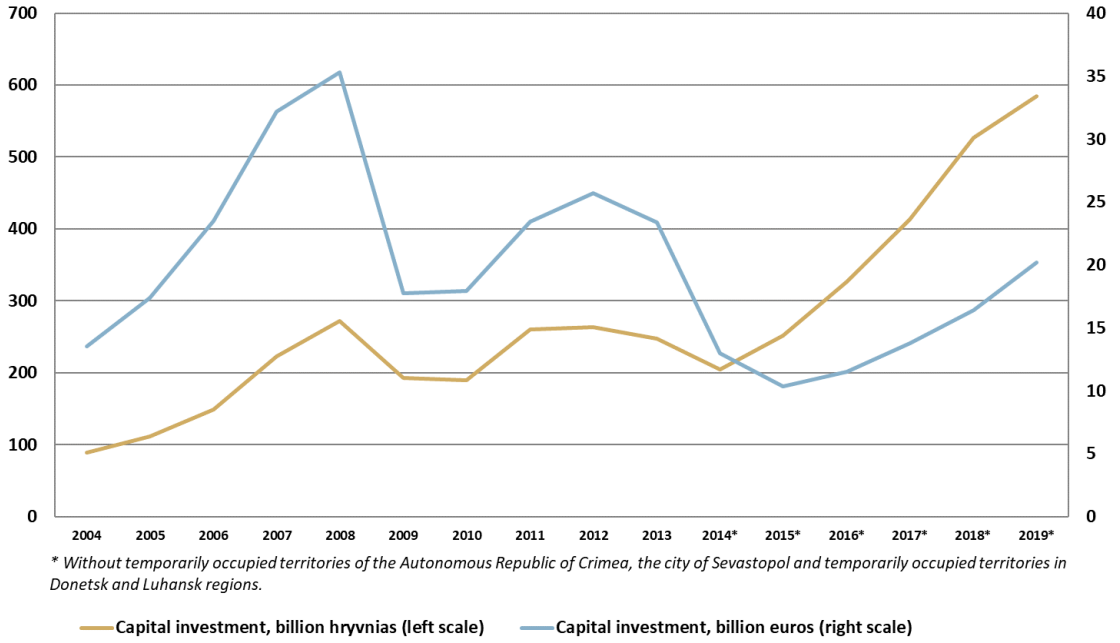


Figure 4.1. Capital investments in Ukraine in the period 2004–2019

Table 4.1 summarizes the estimated public and private finance flows for the total capital investments projected over the 2021–2030 period.

Table 4.1. Total estimated public[40] versus private finance flow for the total CAPEX (2021–2030)

	Public		Private		Sum	
	Mln EUR	%	Mln EUR	%	Mln EUR	%
Totals:	90 638	100.0	172 124	100.0	262 762	100.0
1+2. Energy + industrial processes and product use	87 862	96.9	168 616	98.0	256 479	97.6
Agriculture	*623*	*0.7*	*1 541*	*0.9*	*2 164*	*0.8*
Commercial	*3 396*	*3.7*	*8 403*	*4.9*	*11 800*	*4.5*
ELC and heat	*7 485*	*8.3*	*18 520*	*10.8*	*26 005*	*9.9*
Industry	*10 735*	*11.8*	*26 561*	*15.4*	*37 296*	*14.2*
Residential	*28 967*	*32.0*	*22 899*	*13.3*	*51 866*	*19.7*
Supply sector	*3 116*	*3.4*	*7 709*	*4.5*	*10 825*	*4.1*
Transport	*33 540*	*37.0*	*82 983*	*48.2*	*116 523*	*44.3*
3. Agriculture	958	1.1	1 210	0.7	2 168	0.8
4. Land use, land use change and forestry	808	0.9	1 021	0.6	1 830	0.7
5. Waste	1 010	1.1	1 276	0.7	2 285	0.9

The analysis, built on the financial flow categorization applied by the State Statistics Service of Ukraine, shows the allocation of financing responsibilities to the different financial actors depending on the general characteristics of the targeted sectors. For energy and industrial

[40] Public funding refers to both state and local budgets as well as enterprises' own funds channelled through state-owned or controlled enterprises, with the latter representing two-thirds of all public capital flows.

processes and product use (1+2), the projected public[41]–private finance leverage ratios range between 1:0.8 and 1:2.5.[42] Public funding in this case refers to both state and local budgets as well as enterprises' own funds channelled through state-owned or controlled enterprises, with the latter representing two-thirds of all "public" capital flows assumed in our analysis.

Financing Mix for Incremental Capital Investments

To present insights into the financial resources required to close the incremental investment gap observed between the combined scenario and the BAU scenario, a similar evaluation of financial sources is presented below in Table 4.2, distinguishing between public and private channels of capital. **Over the 10-year period, the cumulative incremental investments equate to 60 billion euros, averaging 6 billion euros per year. These incremental costs represent a 30% rise above the projected BAU CAPEX costs, which are 202 billion euros over the same period.**

It was assumed that all incremental investments have comparable business cases and that the government and other sources of public finance (international) are capable of delivering the same level of support. Since state and local public budgets are finite, a larger share of DFIs and other sources of co-funding is likely to be required, although, for the purpose of this report, no detailed projections on international public finance support were included.

Table 4.2. Total estimated public[43] versus private flow for the incremental CAPEX only (2021–2030)

	Public		Private		Sum	
	Mln EUR	%	Mln EUR	%	Mln EUR	%
Totals:	18 082	*100.0*	42 652	*100.0*	60 733	*100.0*
1+2. Energy + industrial processes and product use	15 516	*85.8*	39 410	*92.4*	54 926	*90.4*
Agriculture	*456*	*2.5*	*1 129*	*2.6*	*1 585*	*2.6*
Commercial	*614*	*3.4*	*1 519*	*3.6*	*2 133*	*3.5*
ELC and heat	*3 376*	*18.7*	*8 354*	*19.6*	*11 730*	*19.3*
Industry	*2 147*	*11.9*	*5 312*	*12.5*	*7 459*	*12.3*
Residential	*- 606*	*-3.4*	*-479*	*-1.1*	*-1 086*	*-1.8*
Supply sector	*2 503*	*13.8*	*6 192*	*14.5*	*8 695*	*14.3*
Transport	*7 026*	*38.9*	*17 384*	*40.8*	*24 410*	*40.2*
3. Agriculture	958	*5.3*	1 210	*2.8*	2 168	*3.6*
4. Land use, land use change and forestry	790	*4.4*	998	*2.3*	1 788	*2.9*
5. Waste	818	*4.5*	1 033	*2.4*	1 851	*3.0*

Across all sectors, enterprises' own funds and bank loans are expected to deliver nearly 90% of the total financial resources. **The role of state and local budgets, albeit fluctuating per sector, is estimated to be responsible for just under 7% of the total CAPEX, which is in line with the historical share that domestic public finance has accounted for in capital investments in Ukraine.**

[41] Defined here as a combination of state and local budgets and support from DFIs.
[42] Defined here as the capital investment sourced from the private sector for each euro invested by the public sector.
[43] Public funding refers to both state and local budgets as well as enterprises' own funds channelled through state-owned or controlled enterprises, with the latter representing two-thirds of all public capital flows.

4.3 PUBLIC CLIMATE FINANCE

Achieving the necessary scale and pace of sustainable investment will require a strong political commitment underpinned by a dynamic and coordinated public financing strategy. A critical goal of the design of Ukraine's climate finance strategy is to ensure that scarce public funds will be used to mobilize private finance investment most effectively. Ukraine's future public climate finance will therefore need to be channelled through mechanisms that reduce critical risks, enhance returns and spur the creation of new investment vehicles that derisk private sector investments across sectors.

State and Local Budgets

In developed countries, private sector resources account for roughly two-thirds of financing through debt or equity for low-carbon infrastructure. Public sector resources, such as national governments, local governments and national development banks, provide the remaining one-third.[44] Both state and local budgets will have to play an important enabling role in scaling up capital investments across the various economic sectors, including co-funding a share of the incremental costs associated with a more ambitious NDC. However, **state and local budgets are not forecasted to exceed 7%[45] of the total CAPEX projected over the 2021–2030 period, which is in line with the historical share of domestic public finance in capital investments in Ukraine**.

Continued direct financial incentives in the form of loans and grants that aim to reduce capital expenditures, operating expenditures or tax expenditures (foregone revenues) will be an important element of the use of state and local public funds. On one hand, capital expenditures in climate change-related activities often represent expenditures on capital projects with long economic lifetimes, with Ukraine's current national capital spending prioritizing investments in housing and public infrastructure.[46] Operating expenditures, on the other hand, aim to support ongoing projects and policies and can include maintenance costs, employee salaries or running CAPEX. Finally, the Ukrainian Government should consider extending the tax breaks to stimulate green investments that it has already introduced, for instance, through the import/sales VAT and excise duty exemptions on electric vehicles. Other regulatory approaches include the introduction of taxes, tradable allowances or financial market regulations.

Ukraine already has a long track record of channelling state and local public funds through concessional debt, grants or subsidies that successfully leverage private investment. Common structures through which these public funds flow include public–private partnerships, inter-municipal cooperation and "warm loans", with the potential to add green bond instruments to the mix currently being discussed.[47] Inter-municipal cooperation, whereby local governments buy or sell services among one another or provide a service jointly, is another significant source of climate support in Ukraine, with over 100 agreements relating to the improvement of the environment having been signed between 2015 and 2020.

[44] Anbumozhi, V., Kalirajan, K. and Kimura, F. 2018. Financing for Low-Carbon Energy Transition: Unlocking the Potential of Private Capital. ISBN 978-981-10-8582-6.
[45] After adjusting the expected public-to-private sector ratios for future capital expenditures and thereby (i) increasing the role of state and local budgets in the agriculture, land use and waste sectors while (ii) reducing the role of state and local budgets in all energy and industrial process-related sectors, the combined role of state and local budgets for the 2021–2030 period in the combined sensitivity scenario is forecasted to be 7% (i.e. below the historical 9% share).
[46] State Statistics Service of Ukraine. 2019. The Structure of Capital Expenditures of State and Local Budgets in 2019
[47] Nasdaq. 2021. Ukraine Discussing Green Bond Issue with IMF To Pay Renewable Energy Debt. https://bit.ly/3jMIOg0

According to our projections, state and local budgets should provide around 4 billion euros in total or around 7% of the total incremental costs associated with the combined sensitivity scenario (0.4 bln euros per year). This figure is in addition to the 7 bln euros already projected in the BAU scenario.

Despite the merits of addressing certain aspects of climate change at the subnational level, the substantial variation in local state capacities and procedures presents challenges, which – combined with the lack of common metrics and climate change reporting[48] – can hamper the timely disbursement of national climate finance resources. For this reason, the planned operationalization of a dedicated national climate fund can be an attractive strategy for Ukraine to pursue longer-term investments in green growth.

Development Finance Institutions

An important source of public finance available for Ukraine to invest in decarbonization and green growth will continue to be bilateral and multilateral financing delivered through development finance institutions (DFIs).[49] DFIs can provide capital at a low cost due to the high volumes of funding that they receive from member countries as well as sovereign backing from member countries, both contributing to high credit rating levels (up to AAA or equivalent). In addition, DFIs may have a specific mandate or target for climate investments and typically have a greater appetite for risk than private investors. These factors position DFIs well to assume subordinated capital positions or provide concessional finance for a share of the targeted investments, allowing for improved risk–return dynamics for private financiers who are active in Ukraine.

The mismatch between the long-term financing needs of low-carbon development projects and the maturities offered by market actors continues to be a barrier for investors in Ukraine. For instance, the adoption of the Basel III regulations by financial institutions limits domestic banks' ability to invest in long-term (green) projects given the specific liquidity requirements. As DFIs have mandates to take longer perspectives, they can play a key role in breaking down these barriers and unlocking private investment opportunities. Such tools make DFIs adept at using leveraging strategies to scale up their investments, and, while leverage ratios are difficult to compare across sectors, estimates often reach 1:5 and above. For example, DFI funds channelled through the Clean Technology Fund (CTF) achieved a leverage ratio of 1:9 for leveraging private clean energy investment and a ratio of 1:8 for mobilizing co-financing from commercial banks or co-private investors.[50]

DFIs have long been an important catalyst for sustainable investments in the Ukraine, and the country ranks fourth in the world as a recipient of climate finance from these bilateral and multilateral funders.[51] The EU is the leading source of financial support, both through direct budget support and through DFI channels, and EU funding channelled through the EBRD and the

[48] Accurate monitoring of climate finance flows will allow the government to make more informed decisions about the planning, prioritization and allocation of resources to climate change and to measure and evaluate progress. In Section 4, we present a discussion on approaches to climate finance tracking and how this process is critical for improved transparency and accountability towards Ukraine's NDC target.
[49] For purposes of simplicity, in this report, we define DFIs as incorporating bilateral and multilateral development finance institutions as well as multilateral development banks.
[50] Anbumozhi, V., Kalirajan, K. and Kimura, F. 2018. Financing for Low-Carbon Energy Transition: Unlocking the Potential of Private Capital. ISBN 978-981-10-8582-6.
[51] 2019 Joint Report on Multilateral Development Banks' Climate Finance. https://bit.ly/3d6bRdf

EIB has been used to complement the bilateral support given to the Ukrainian Government. Overall, the EU and these two DFIs mobilized over 13 bln euros in loans and 2 bln euros in grants between 2014 and 2019.[52] Loans amounting to 4.6 bln euros have been mobilized by the EIB, specifically to support infrastructure development and reforms in the transport, energy, agriculture, education and municipal sectors. Investment of 4 bln euros from the EBRD has been directed to helping to develop and reform the banking sector, agribusiness, transport and small businesses over this period. In addition to these, the EU's Annual Action Programme in support of Ukraine has been financed under the general budget of the EU and was valued at 165 mln euros across several budget lines for the year 2020 (e.g. support for SMEs; agriculture and small farm development; technical cooperation; civil society; and climate action).[53]

On average, therefore, EU-based DFI flows have averaged at least 1.7 bln euros per year, with EU budget funding averaging an additional 1.3 bln euros per year. It is expected that the EU's financial proposals to enact the EU Green Deal, including the Green Deal Investment Plan and the Just Transition Mechanism, will also trigger a shift in the EU's future financial support for Ukraine, with climate change and related environmental issues taking centre stage in future disbursement agreements.

The government should therefore anticipate that a growing share of future EU funding is likely to be earmarked for the development and implementation of Ukraine's low-carbon development roadmap, which may support the incremental costs associated with a more ambitious NDC target. We project that one-third of the future EU finance for Ukraine will be allocated to such climate-related investments in the 2021–2030 period, amounting to 10 bln euros – or nearly one-fifth of the total incremental funding required – which could be leveraged in support of the identified incremental investments (1 bln euros per year).[54]

Climate Funds

Domestic climate finance efforts can be supported further by climate funds dedicated to helping climate change mitigation and adaptation efforts. In Ukraine, international funds and assistance programmes play a major role in providing climate finance. The resources that they provide support the implementation of projects as well as facilitating the creation policy environment to catalyse further green activity. Significant contributors to date include the Clean Technology Fund (CTF), administered by the World Bank; the Global Environment Facility Trust Fund (GEF), which is operated through the UNDP, UNEP and UNIDO in Ukraine; the Finland–Ukraine Trust Fund, established by NEFCO, and the Eastern Europe Energy Efficiency and Environment Partnership (E5P), launched by the European Commission initially for the sole purpose of supporting Ukraine. In addition to these, the Green Climate Fund – a financial entity serving the UNFCCC – has committed to allowing institutions "direct access" to finance, meaning that national or subnational entities can become accredited to receive finance directly from the fund.

[52] EC. 2020. European Neighbourhood Policy and Enlargement Negotiations: Ukraine. https://bit.ly/3bwQ2RI
[53] EC. 2020. Commission Implementation Decision of 15.5.2020 on the Financing of the Annual Action Programme, Parts 1 & 2, in Favour of Ukraine for 2020. https://bit.ly/3ueXZ6B
[54] Across all the DFIs, climate finance contributions predominantly support energy generation, efficiency and supply projects, followed by transport and infrastructure projects. The total flows to Ukraine, despite decreasing in the 2015 to 2018 period (from 940 mln US dolars to 519 mln US dollars), almost doubled in the subsequent year, reaching 1,115 mln US dollars in 2019. Since the leading DFIs have committed collectively to channelling at least 65 bln US dollars in climate finance annually by 2025 (a figure that is 50% above the 2019 level), it is reasonable to expect that Ukraine will continue to be able to depend on these international climate finance channels throughout the 2021–2030 period.

Ukraine, being an Annex I country to the UNFCCC, however, is not eligible to receive grants from this fund and is not expected to be able to benefit from its climate finance support. Another important mechanism through which Ukraine can manage public climate finance is a national climate fund. A dedicated national climate fund can collect climate finance from a variety of sources and coordinate, blend and account for it. In this way, the government can be in the driving seat and can make informed choices about how to direct resources towards activities that deliver results.

In Ukraine, the establishment of a dedicated climate fund, the Ukrainian Climate Fund (UCF), was announced in November 2020[55] by the Minister of Environmental Protection and Natural Resources. The fund is intended to be structured as a separate legal entity, funded by environmental taxes. Other existing funds that provide support for green and climate-related projects and could take on the function of channelling climate finance include the State Fund for Regional Development (SFRD) and the Energy Efficiency Fund (EEF). The SFRD is a key resource for the implementation of regional development projects and, though not a dedicated climate fund, in the period 2015 to 2020, provided finance or co-finance for 301 climate-related projects. These related to energy efficiency; solid waste management; the use of alternative fuels; and waste collection, sorting, removal and disposal. The EEF, by contrast, currently provides partial compensation for energy efficiency measures adopted by homeowners' associations in multi-apartment buildings.

Fiscal and Climate Policies

In addition to providing direct financial support for climate change mitigation and adaptation activities, the Ukrainian Government should evaluate the options for integrating a more ambitious NDC target into its fiscal planning by considering climate policy instruments and national budgetary policy measures that can help to scale future climate finance flows. These include the expansion of carbon-pricing mechanisms, the redirection of domestic subsidies to stimulate green investment and the introduction of financial market policies that strengthen the investment climate for green investments.

Carbon Pricing

Ukraine's current carbon tax applies to emissions arising from stationary sources in the industry, power and buildings sectors and has been in place since 2011. However, currently, it is priced at UAH 10 per tonne, and, though regulations indicate an intention to raise the price to UAH 40 per tonne by 2023, even at this level, the tax would remain among the lowest in the world.[56] A higher carbon tax would place more pressure on industry to invest in a greener transition pathway, signalling the government's commitment to decarbonizing the economy in the coming decades.

The combined sensitivity scenario provides an initial estimate of the implications that a higher carbon tax could have for raising public funding for low-carbon investments. **When the carbon tax is increased to a level of 5 euros per tonne, the total revenues raised would amount to 9.3 bln euros, or just under 1 bln euros per year. Doubling this tax to a level of 10 euros per tonne would generate cumulative revenues of 18.5 bln euros, equivalent to nearly 2 bln euros per**

[55] EU4Environment. 2020. Creation of the Climate Fund in Ukraine. https://bit.ly/34bWxpP
[56] Climate Action Tracker: Ukraine. Updated July 2020. https://bit.ly/3ryoNMT

year. Over a 10-year period, this would translate into total potential revenue of 20 bln euros, representing one-third of the total incremental funding required.

While such prices may appear high compared with the current level, the prices under the EU-ETS reached a much higher record of 40 euros in February 2021, and the EU is likely to use the EAU price as a benchmark for pricing in the border adjustment tax proposed under the EU Carbon Border Adjustment Mechanism. Increasing taxation domestically (rather than paying the tax at the EU border for exported products) and redirecting these increased revenues to a national climate fund could provide as much as one-third of the incremental CAPEX costs estimated over the 2021–2030 period.

In accordance with the obligations under the Ukraine–EU Association Agreement, Ukraine is also laying the foundations for a domestic emission trading scheme (ETS). The implementation of such a scheme would create an economic incentive for companies to reduce their GHG emissions. The Government of Ukraine has announced that it is working towards a national ETS launch in 2025.[57]

To support the establishment of the scheme, Ukraine has already developed and begun to implement a national monitoring, reporting and verification (MRV) system. The system mandates the reporting of emissions from several industries, including oil refining, coke production and fuel combustion installations of over 20 MW.[58] As such, the framework for generating revenues from carbon pricing in Ukraine is already in place, but a complementary policy is required to encourage the "greening" of BAU activities, such as robust carbon-pricing measures.

Subsidy Reform

Continuing subsidies for carbon-intensive industries create an imbalance in the investment landscape, which lowers the market pressure to meet the scaled-up need for green investments. The existing subsidies create high barriers to market entry, providing investors with reduced competition whilst putting investors in low-carbon assets at a competitive disadvantage. The rising reliance on natural gas as a green "transition fuel" also introduces this risk as today's national subsidies create long-term risks of carbon lock-in and stranded assets.

Gradually phasing these subsidy payments out would free up national budget allocations, which in part could be redirected to support investments in low-carbon development. The Ukrainian Government has already made some efforts to reform its fossil fuel subsidies, with some of the generated savings being rechannelled to targeted subsidies for low-income households and energy-efficiency programmes in the residential sector. More extensive tax exemptions could be considered for renewables, energy efficiency measures and zero-emission vehicles as well as the delivery of CAPEX subsidy support for industrial energy-saving measures.

Through such measures, the fiscal policy can help financiers to overcome the investment barriers. The upfront commitments, in turn, can be recouped through other forms of taxation as levies, helping to balance future public budgets.[59]

[57] International Carbon Action Partnership. 2021. Ukraine Plans To Launch ETS in 2025. https://bit.ly/3jCx1Rd
[58] International Carbon Action Partnership. 2021. Ukraine Plans To Launch ETS in 2025. https://bit.ly/3jCx1Rd
[59] Between 2016 and 2019, the taxes and levies collected from the renewable energy sector for the Ukrainian state budget were UAH 67 bln (2.7 bln US dollars), making the sector one of the largest taxpayers in the country. https://bit.ly/3tUf2L4

Greening Financial Markets

Sustainability Taxonomies

A lack of clarity over definitions of "green" and "sustainable" investments is an often-cited barrier to accelerating green investment. Sustainability taxonomies can be a highly effective mechanism to overcome this barrier by clearly defining the types of investment that should be deemed "sustainable" and in doing so support financial institutions in making better-informed investment decisions. Taxonomies can also facilitate better tracking of sustainable finance flows, which can both inform subsequent policy action and help to measure progress against targets.

The EU pioneered this approach with the introduction of a sustainability taxonomy in 2020 as part of the EU Sustainable Finance Action Plan. The EU taxonomy requires financial sector participants offering products in Europe to align their financial disclosures with criteria defined in the regulation by the end of 2021, with the aim of catalysing finance flows that support the transition to a net-zero economy.[60, 61] In addition to providing market clarity, its introduction will also create an enabling legislative environment for companies to issue green bonds while ensuring that their revenues are used for the implementation of environmental projects.

The introduction of a taxonomy that also takes into account the context of the Ukrainian market, while harmonizing with the emerging international best practices, will thereby become an important lever for sustainable foreign direct investments in Ukraine.

Shadow Pricing

A shadow price imposes a theoretical or assumed cost per ton of carbon emissions, which can help businesses to understand better the potential impact of external carbon pricing on the profitability of a new investment. The recognition of the use of shadow pricing in financial decision making has been highlighted by the Task Force on Climate-Related Financial Disclosures (TCFD), developed by the Financial Stability Board.[62] As with the taxonomy, the widespread uptake of shadow pricing in Ukraine could provide financial markets with the necessary knowledge on the risks and opportunities posed by climate change, at the same time triggering the introduction of green financial instruments.

4.4 PRIVATE CLIMATE FINANCE

According to the incremental cost projection (Table 4.2), **private sector finance must account for around 42 bln euros during the 2021–2030 period, implying that each euro of public financing (both domestic and international) will, on average, need to leverage around 2 euros in private sector finance**. This generally assumed leverage ratio will vary considerably, however, depending on the sector and the underlying business case for private sector investors as well as the level of incremental costs that need to be covered. The degree to which private capital can be leveraged to realize investments is highly dependent on the individual risk–return profiles of the targeted investment and the regulatory environment in which these investors operate.

[60] Technical Annex to the TEG's final report on the EU taxonomy. https://bit.ly/3sudEhq
[61] Other jurisdictions that recognize the potential of sustainability taxonomies – and the mechanisms that they facilitate – include China, which introduced a similar taxonomy in 2015; Japan, which launched green bond guidelines in 2017; and the Netherlands, which has embedded green criteria into its lending legislation since 1995 in its "Green Funds Scheme". Other countries expressing an interest in sustainable finance taxonomies include Canada, Kazakhstan and Indonesia.
[62] The TCFD recommendations are aimed at enabling institutions to make better-informed investment, credit and underwriting decisions and in turn enabling stakeholders to understand their exposure to climate-related risk.

Corporate Investment

Corporations in Ukraine are expected to play an increasingly important role in mobilizing internal funding for green investments. There are different motivations for this, which influence the scope and scale of the investments and financial contributions that corporations will be able to offer.

Corporations increasingly recognize a positive financial business case for shifting to less carbon-intensive modes of production due to looming regulatory risks related to the onset of carbon-pricing mechanisms, such as higher carbon taxes or the introduction of an ETS. Unmanaged exposure to carbon-intensive assets can be detrimental in the long term, and divestment from certain assets or business lines may be necessary to limit future liabilities. Recommendations by initiatives such as the TCFD stress the importance of companies evaluating climate policy risks in long-term capital investment decisions, and a growing number of companies are building on these guidelines to strengthen their internal safeguards against future carbon-pricing risks. One study on the application of such "climate value at risk" quantified the risk at 3% of global financial assets, assuming a business-as-usual emission path, which is equivalent to 4.2 trillion US dollars.[63]

In Ukraine, climate change poses diverse risks across a multitude of sectors. In the agricultural sector, which dominates around 70% of the country's land area, crops – particularly grains – are threatened by changes in precipitation and shifting seasons, which present risks of decreasing soil fertility and resulting crop quality. In the energy sector, rising temperatures and the increased frequency of extreme weather conditions jeopardize the production and supply of energy – with high reliance on coal and natural gas units increasing the vulnerability to poor performance efficiency, breakdown and failure.

Another important development is the increasing awareness among end-consumers of the effects of corporations' impact on the climate. The demand is – albeit gradually – shifting towards environment-friendly production processes, and consumers are increasingly willing to reward low-carbon products with higher pricing, whereas they are progressively frowning upon carbon-intensive products. Given this demand shift, corporations will have an increasingly strong financial incentive to adjust their processes accordingly, in addition to their existing CSR projects.

Finally, it is anticipated that gaining access to finance will become increasingly challenging for corporations with carbon-intensive production as banking regulations evolve to become less tolerant of corporations with a poor carbon status (an example of this is the EU taxonomy). Consequently, corporations will be driven to manage their carbon footprint to maintain their funding.

These factors, combined with shareholder pressure or resolutions calling for more corporate responsibility regarding climate issues in general, will prompt corporations to scale up their investments in low-carbon and green activities, providing a primary source of private sector co-funding for investments associated with the green transition.

[63] The Economist Intelligence Unit. 2015. The Cost of Inaction: Recognising the Value at Risk from Climate Change. https://bit.ly/3aomKFn

Financial Institutions

Over the next decade, banking regulations are expected to be tightened and financial institutions will be required to scrutinize further their loan/investment portfolios on ESG themes, particularly environmental and climate topics. As a result, it can be anticipated that financial institutions in Ukraine will increasingly shift towards investments that have positive implications for the climate and can evidence alignment with low-carbon development pathways.

The **banking sector** in Ukraine is dominated by state banks (Privatbank, Oschadbank, Ukreximbank and Ukrgasbank) and several international commercial institutions (e.g. Alfa Bank, Raiffeisen and BNP). All the state banks already have a track record in operating energy efficiency credit programmes, with certain institutions (e.g. Ukrgasbank) playing a leading role in financing renewable energy investments. The restructuring of the banking sector following the financial crisis of 2008–2009 has strengthened ownership structures, adequately recapitalized cash positions and reduced exposures to related party risks. With the implementation of the Basel III standards, the risks to financial stability are at their lowest level in history, according to the National Bank of Ukraine. In aggregate, the Ukrainian banking sector was profitable again in 2018 for the first time since 2013, being a leading performer across the Central and Eastern Europe region.[64] Looking ahead, the robust state of the domestic banking sector also supports the scaling up of green banking activities, which offer an opportunity to be a pioneer in a market that remains underdeveloped. Ukrgasbank has been the frontrunner in reshaping itself into a leading climate finance bank, with Euromoney acknowledging the bank as the best bank for sustainable finance across Central and Eastern Europe in 2019. As other state banks and international service providers enter the green finance space, the offer of green loans for mid- to large-scale climate projects is expected to grow gradually in the years to come.[65]

In addition, there is an increasing gap that can be filled by **insurance and pension funds**. Not only do these organizations have vast sums seeking stable returns, but they can also turn to (green) investments to diversify their investment portfolio. In addition, the investment horizons for this category are typically long, aligning with the duration of many climate investments. Through climate-related investments, stronger asset liability management will be possible for institutional investors. In particular, the role that insurance companies and pension funds can play in driving the development of green/climate bonds as buyers is noteworthy. **As Ukraine continues its restructuring of the energy sector, scaled-up finance flows through green bond issuances could provide at least[66] a portion of the required private sector co-funding. Similarly, given the large role that capital investments in the transport sector are forecasted to play in the period 2021–2030, green bonds could also serve to provide these investments with long-term debt finance.**

Finally, green investments managed by **private equity funds**, while representing a small share of the total private finance flows, can play an important role in financing higher-risk ventures that invest in innovative climate change solutions. Especially if concessional funding can be attracted through DFIs or the government, blending will allow the crowding in of private equity investments that factor climate change into their investment decisions.

[64] Raiffeisen. 2019. Raiffeisen Research: CEE Banking Sector Report. https://bit.ly/3jV0tlB
[65] IFC. 2021. Ukraine's First Green Finance Bank Backs Climate-Smart Businesses. https://bit.ly/3pgDumc
[66] According to the IFC, Ukraine's green bonds market could reach 73 bln US dollars by 2030. https://bit.ly/3dZ9h9i

4.5 CLIMATE FINANCE TRACKING

In the context of international climate finance, it is crucial to determine the status of finance flows accurately to reveal whether pledges are being met and whether finance is reaching recipients. At present, increased monitoring of climate finance is needed to ascertain whether countries are on track to meet their climate finance commitments, especially since pledges for mobilizing climate finance under the UNFCCC are based on a principle of mutual accountability. The tracking of climate mitigation and adaptation finance should be "comparable, transparent and accurate", enable parties to the UNFCCC to build trust and accountability regarding climate finance commitments and monitor trends and progress in climate-related investments. As such, Ukraine should closely follow the discussions on enhanced transparency and finance tracking under the Paris Agreement and operationalize systems that allow for effective data collection and the reporting of climate finance flows.

The Common Principles developed by MDBs to define common ways to track climate finance are among the most widely adopted approaches. They constitute an activity-based tracking approach for both mitigation and adaptation measures, whereby finance is classified according to a common list of eligible categories.[67]

Such high-level categorization of investments can help Ukraine in tracking its progress on the implementation of actions that align with low-carbon development more accurately and gaining a clearer understanding of the mix of financial sources and instruments that is needed to close the financing gaps. This, in turn, can help the government to assess the current and planned investments and target policy efforts to mobilize additional finance to fill the gap. Figure 4.2 shows these interactions.

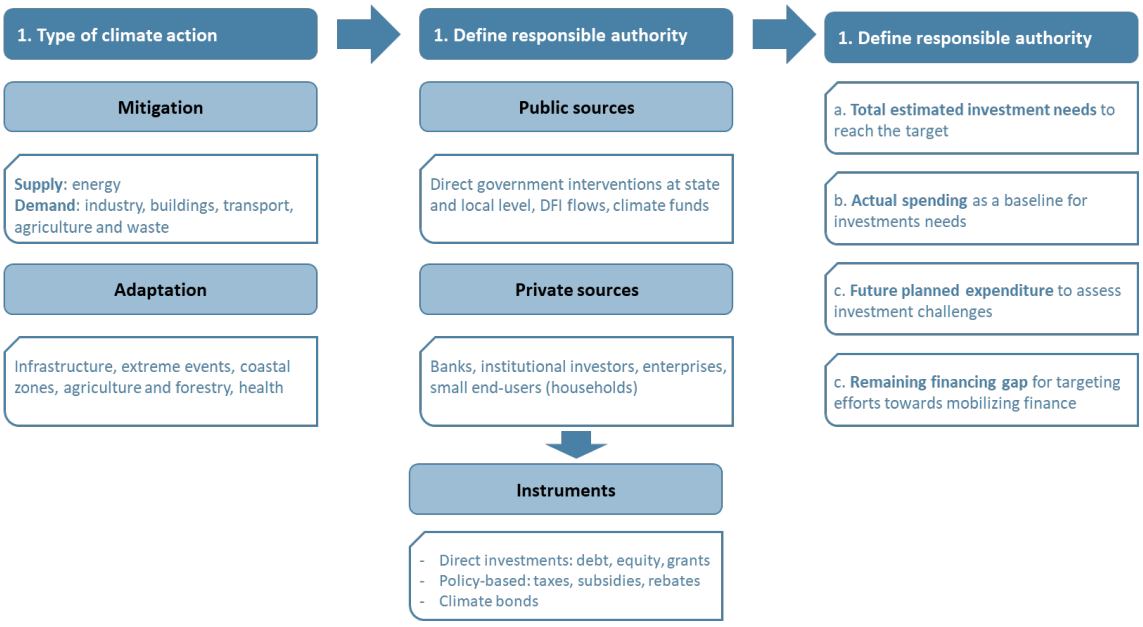


Figure 4.2. Domestic climate finance landscape[68]

[67] When assessing these principles, the MDB approach also advises on considering the following attributes: additionality, timeline (project reporting is ex ante), conservativeness (in data reporting), granularity (proportion of the mitigation activities), scope, mitigation results (quantitative evidence of GHG emission mitigation), eligibility (compatible with long-term low-emission pathways), exclusions (projects that are included in the list but do not mitigate emissions) and the avoidance of double counting (between mitigation and adaptation).

[68] Own elaboration based on Trinomics. 2017. Assessing the State-of-Play of Climate Finance Tracking in Europe. https://bit.ly/3ar35EV

Climate finance governance requires the government to play a leading role in providing the institutional capacity to ensure the ability to track climate finance flows on both state and local levels. In Ukraine, the Ministry of Energy and Environmental Protection (with validation by the Ministry of Finance, among others) has been in charge of preparing annual GHG inventory submissions and publishing national communications and biennial reports to the UNFCCC. The enhanced transparency framework under the Paris Agreement includes both the need for continuous enhancement of the existing National GHG Inventory Systems (Article 13.7a) and the progress made in implementing the NDCs (Article 13.7b) as well as the promotion of effective NDC implementation through the provision of clarity on the financial support provided and received by individual parties (to inform the global stocktake under Article 14).[69]

Developing a robust climate finance-tracking framework targeting supported actions requires the definition of clear rules and the adoption of consistent methodologies for measuring and reporting flows. It must also not only facilitate the uptake by public actors (e.g. linked to public infrastructure finance) but also incentivize private sector financiers (e.g. banks, institutional investors and equity investors) to start aligning their approaches to tracking financial flows.[70]

Figure 4.3 summarizes the key general steps for establishing domestic climate finance-tracking processes, which will need to be worked out in further detail by the government as it builds on the measurement, reporting and verification system already in place and extends this to monitoring both public and private finance and support, including finance from both international and national channels.

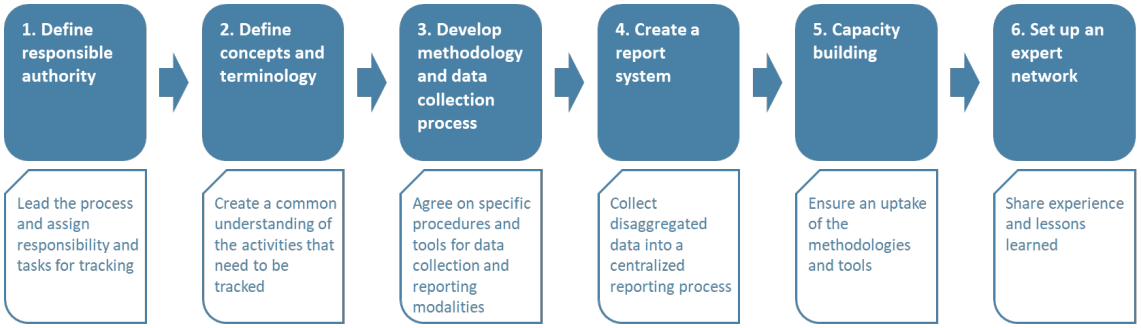


Figure 4.3. Roadmap for setting a domestic climate finance landscape[71]

[69] UNFCCC. 2019. What Is Transparency and Reporting? https://bit.ly/37m2rqh
[70] Beyond the framework's understanding, the government should develop regulations to encourage its adoption, such as introducing mandatory disclosure rules for relevant climate investment data.
[71] Own elaboration based on Trinomics. 2017. Assessing the State-of-Play of Climate Finance Tracking in Europe. https://bit.ly/3ar35EV

SECTION 5. SUSTAINABLE DEVELOPMENT AND UKRAINE'S UPDATED NDC

5.1 UPDATED UKRAINIAN NDC AND SDG LINKAGES AND ALIGNMENT

The 2030 Agenda for Sustainable Development and the Paris Agreement on climate change were negotiated in parallel and adopted in 2015. The SDGs, which form the centrepiece of the 2030 UN Sustainable Development Agenda, include SDG13: "Take urgent action to combat climate change and its impacts" on tackling climate change and its impacts. This reflects the recognition that future actions to achieve social and economic objectives will require alignment with climate change objectives.

The project conducted an analysis of the existing and potential linkages, alignment and co-benefits of the proposed policies and measures for implementing the updated NDC with the national sustainable development agenda and relevant SDGs. This analysis showed that every NDC policy or measure is linked to at least four Sustainable Development Goals. Such linkages reflect the strong influence of the proposed NDC policies and measures on the national achievement of the Sustainable Development Agenda, its pathways and its potential priorities.

The interlinkages between the Sustainable Development Agenda and the updated NDC implementation process are well understood by the GoU, and, in September 2019, the UN Sustainable Development Goals were adopted as national SDGs by the relevant Presidential Decree on Sustainable Development Goals of Ukraine till 2030. The fundamental nature of sustainability of national development and its paramount importance for the national strategic planning processes are reflected in this Decree, which requires "ensuring the compliance of national policies with SDGs, while taking into account Ukraine's national circumstances and incorporating SDGs into existing and planned forecasting and programming policy documents".

The importance of pursuing economic development in a sustainable manner while contributing to combating global climate change is enshrined in the National Economic Development Strategy until 2030, recently adopted by the GoU, which defined its mission as "creating opportunities for realization of existing geographical, natural and human resource potential of the country for ensuring a decent level of welfare, self-realization, security, rights and freedoms for each citizen of Ukraine through innovative advanced economic growth **taking into account the SDGs** and the need for achieving **climate neutrality no later than 2060**". The economic strategy also defines, as one of its first key priorities, the decarbonization of the economy through increasing energy efficiency, the development of renewable energy and the circular economy and the synchronization of the European Green Deal initiative.

Proposed NDC policies and measures are putting Ukraine on a pathway to achieving the Sustainable Development Agenda in the most ambitious way for the climate while taking into account the national circumstances and green transition trends. Achieving goals for sustainable consumption and production, building resilient infrastructure, promoting inclusive and sustainable economic growth and ensuring access to affordable and sustainable energy will represent the core challenges on the pathway to implementing the NDC and achieving the Sustainable Development Agenda nationally in a comprehensive manner.

A coherent approach to NDC implementation and the SDGs is vital for pursuing the green transformation pathway in Ukraine. Direction 20 "Quality of Life" of the National Economic

Strategy until 2030 covers most of the climate change and sustainable development-related goals, targets and activities, including NDC development and adoption and the achievement of national targets under the UN SDGs (1, 3–6 and 10–16).

Ukraine's Government does not allocate public funds to the SDGs' achievement as yet, but, at the same time, Ukraine is part of the Joint SDGs Fund and currently has an operational international technical assistance project, "Promoting SDGs Financing in Ukraine",[72] implemented by the UNDP, which aims to support Ukraine on the pathway to achieving SDG-1 (no poverty), SDG-3 (good health and well-being), SDG-5 (gender equality), SDG-16 (peace, justice and strong institutions) and SDG-17 (partnership for the goals).

5.2 JUST TRANSITION OF THE WORKFORCE AND THE CREATION OF DECENT WORK AND QUALITY JOBS

The international community recognized the importance of the social dimension within the Paris Agreement framework by stating in its preamble that all climate actions should be developed and implemented while "taking into account the imperatives of **a just transition of the workforce and the creation of decent work and quality jobs** in accordance with nationally defined development priorities". The UN Sustainable Development Agenda 2030 in SDG-8 highlights the need for inclusive and sustainable economic growth, employment and decent work for all. Climate change impacts could influence or even limit the achievement of SDG-8 in Ukraine, especially in the agriculture sector and other sectors that are particularly vulnerable to the impact of climate change, such as health care, water management and protection, forestry and energy, and in vulnerable and unprotected communities in other sectors, including informal and youth workers.

To build further on this just transition element of the Paris Agreement, the UN International Labour Organization developed a comprehensive document called *Guidelines for a Just Transition towards Environmentally Sustainable Economies and Societies for All*, which was the result of a long multilateral negotiation process between trade unions, businesses, employers' organizations and governments in 2015. While transferring to low-emission economies, industries and societies, it is important to remember that there are potential positive and negative impacts on employment. Employment in fossil fuel energy, coal mining and heavy industry will decline, while the expected employment in energy efficiency, renewable energy and other impact investment sectors will increase.

Two major impacts of relevant climate change policies could be expected along the way – the qualitative impact, which concerns the quality of the jobs created and/or transformed, and the quantitative impact, which, in simple terms, means the number of jobs affected by climate change policies. A specific example of the most socially sensitive sectoral policy for Ukraine, which has been in the process of tackling the issue of the just transition of the workforce as a result of climate-related national policies, called the "Concept of Ukrainian Coal Regions Transformation until 2030", has recently been developed and presented by the GoU for public discussion. The concept introduces the principles of just transition, creation of decent jobs, social protection of senior and youth workers, continuous education principles for adults and other related goals and principles that will potentially lead the transformation of coal-mining

[72] https://jointsdgfund.org/programme/promoting-strategic-planning-and-financing-sustainable-development-national-and-regional

regions into new sustainable and healthier communities with government-protected decent equal access to quality jobs. This is the first pilot policy for Ukraine on economic diversification and the creation of decent jobs for industrial regions and is supported by similar EU initiatives.

5.3 COHERENT UPDATED NDC AND SDG IMPLEMENTATION

While remembering that sustainable development is development with sustainability that "meets the needs of the present without compromising the ability of future generations to meet their own needs" and recognizing the challenges of the global climate crisis, Ukraine could make an ambitious contribution to combating global climate change by transforming its 25-year-long trend of continuous economic decline into sustainable social–economic growth and continuous green transformation on the pathway to climate neutrality. This could unfold additional opportunities for people, the economy and ecosystems. The proposed NDC implementation policies and measures should be performed by the GoU while keeping in mind the following:

1. **Policy and measure level**. Prioritize innovative sustainable environmental policy approaches over traditional energy and agriculture policies.
2. **Financial instrument level**. Introduce innovative climate financial instruments to facilitate both mitigation and adaptation, such as sovereign green bonds, special purpose funds, blended finance instruments, other market and non-market instruments, green procurement and taxonomy.
3. **Institutional and governance level**. Broaden the application of public–private partnership mechanisms and introduce "pilot" national and regional programmes and projects under Articles 3 and 6 of the Paris Agreement (before the "Paris Rulebook" is adopted).
4. **Scientific and research level**. Introduce integrated R&D organizations for systematic observations and national sustainable strategy planning with a view to tackling global climate change while considering the COVID-19 pandemic and post-pandemic aftermaths and implications as well as the application of technology development and transfer mechanisms.

SECTION 6. UKRAINE'S UPDATED NDC REPORTING AND TRANSPARENCY SYSTEM

The Paris Agreement established its transparency system with Article 13 to enhance the understanding of climate actions as set out in its Article of the Convention 2, including clarity and tracking of progress towards the achievement of the parties' individual NDCs under Article 4 and the parties' adaptation actions under Article 7, and to inform the global stocktake under Article 14. To enhance the Paris Agreement's integrity further, the parties established the so-called **Enhanced Transparency Framework**, which is currently at its operationalization stage.[73] The main purpose of this Enhanced Transparency Framework is to increase the understanding and build a transparent NDC accounting system that will strengthen the global response to the threats of climate change while tracking the progress of each party towards its NDC targets and goals.

The transparency framework, introduced by the Paris Agreement, refers to country reporting, including the GHG inventory, accounting rules and indicators to track the progress towards NDC targets and the support provided and received. Transparency's importance has a dual nature – communicating the NDC and tracking progress towards its implementation, including NDC accounting, and establishing the so-called transparency cycle (marked as Step 2 in Figure 6.1 below).

The detailed **modalities, procedures and guidelines (MPGs) for the transparency framework of action and support** are referred to in Article 13 of the Paris Agreement adopted by Decision 1/CP.21, paragraph 91, and CMA Decision 18/CMA.1.

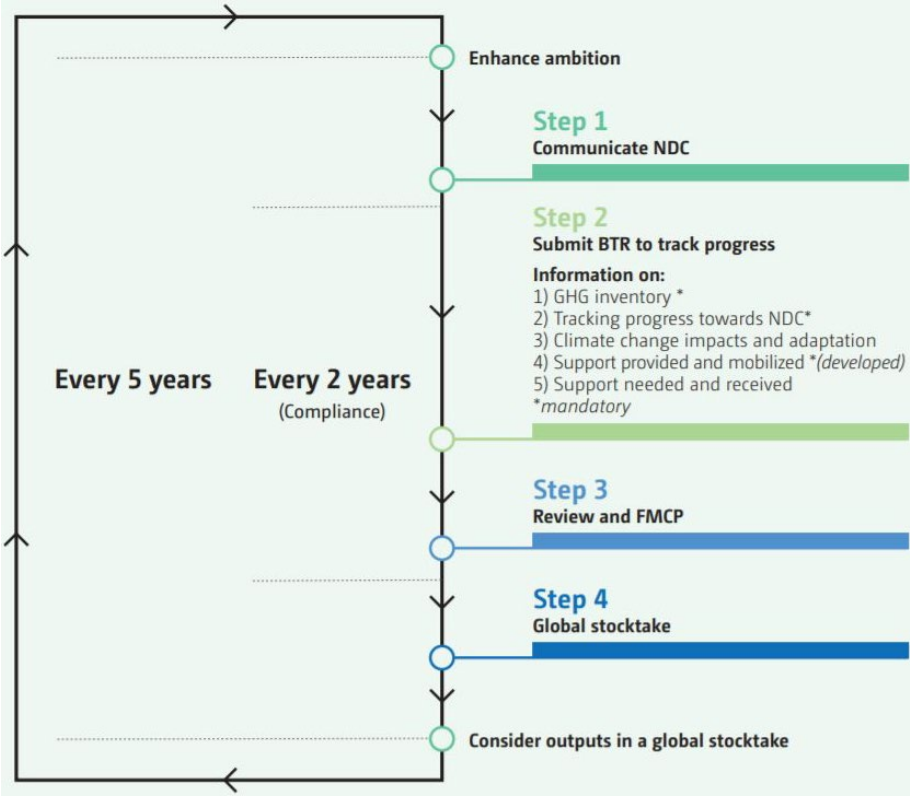


Figure 6.1. Stepwise circular approach of the transparency system under the PA[74]

[73] https://unfccc.int/enhanced-transparency-framework
[74] https://unfccc.int/sites/default/files/resource/ETFReferenceManual.pdf

Ukraine's National GHG Inventory System

Ukraine already has a comprehensive National GHG Inventory System in place with a specific state entity in charge of maintaining this system and developing annual GHG inventory reporting. Ukraine's National Inventory System (NIS) was established in April 2006 by the Cabinet of Ministers' Resolution "On Approval of the Regulations on the National System for Estimation of Anthropogenic Emissions and Sinks of Greenhouse Gases not Regulated under Montreal Protocol on Ozone Layer Depleting Substances".

Transparency Framework Enhancement Recommendations

It is recommended that Paris Agreement MPG reporting builds on previous and existing reporting, including Ukraine's NDC GHG emission projections, Ukraine's National Communication Reports and Ukraine's BTRs, to ensure consistency and comparability not only between different types of reports but also throughout the timeline to guarantee methodological consistency of scope and estimations/projections. Such a consistent methodological approach will enhance the transparency, enable the comparability of data and allow the building of long-term trajectories between different submissions of the same types of reports and intra-reports (e.g. NDC and updated NDC, the BTRs, national communications, long-term strategies and adaptation communications). To achieve this aim, Ukraine plans to enhance its legislative, institutional and organizational capacities and build knowledge throughout the National GHG Inventory System, including integrating MRV and ETS elements into the national GHG inventory system.

Meantime, there are new elements of reporting that are introduced by the MPGs and need to be combined with the existing national GHG inventory system. This information mainly concerns enhancing adaptation planning, implementation and reporting (the Adaptation Communication Report) and finance and technology development and transfer. Finance and technology information was reported previously but with a limited scope; therefore, it is **recommended** that the GoU establishes a monitoring system for climate-related finance, technology transfer and capacity building. The following elements are **recommended** for further streamlining of intra-reporting: inter alia, policies' and measures' targets in the National Communications and the NDC tracking and achievement in the BTR, research and systematic observation and public awareness.

1. Further enhancement of the transparency framework is recommended to ensure the collection of the required new data and information, which is currently collected in the NIR, NC and BR reporting process, with a much narrower scope. As a result, once enforced, the BTR under the Paris Agreement will contain all the required information.

2. The NIR needs to remain an essential part of this transparency framework as, being submitted as a separate document or part of the BTR, it will require a solid and reliable GHG inventory system and reporting preparation. Ukraine currently has an inventory system, which performs its task successfully, and this has been confirmed by regular reviews undertaken by international expert review teams during the UNFCCC's relevant regular review process. It is recommended that the national GHG inventory system should be maintained and improved on a continuous basis with the development of a regular enhancement plan and the establishment of a proper M&E system to meet the MPGs' requirement of continuous improvement over time.

3. The Government of Ukraine should consider establishing a legal, institutional and organizational framework for tracking the implementation of the NDC in parallel with

the process of updating the NDC or developing the next one. Reporting the progress towards the achievement of parties' NDCs is one of the main milestones of the MPGs. The level of detail and frequency of information required by the MPGs requires, in turn, a strong domestic system that should allow the collection and/or generation of this information and its communication through the BTR.

4. Ukraine needs to establish a national reporting system to support finance, technology transfer and capacity building, which will require extensive stakeholder discussions (mainly among ministries and agencies) as well as the possible establishment of legal, institutional and organizational arrangements.

5. Ukraine urgently needs to start designing and establishing an efficient national system for a continuous and reliable reporting framework under the UNFCCC and PA to ensure the submission of timely, robust, transparent and comprehensive mandatory reports, with continual enhancement over time to ensure comparability of data, information and projections, including those related to NDC reporting and tracking. In developing such arrangements, it is worth considering – building on the capacities of the existing entities within the GoU that are in charge of GHG emission accounting, projections, climate change impact estimations and state finance accounting, such as NCI – the possible development of the existing capacities to comply with and fulfil the existing and potential new international reporting requirements under the MPGs and any new potential national monitoring and reporting requirements for climate-related information.

Therefore, the implementation of the MPGs in Ukraine **will require** the maintenance and further enhancement of the national GHG inventory system and the establishment of a system for the regular development and submission of National Communications and Biannual (Transparency) Reports (Figure 6.2).

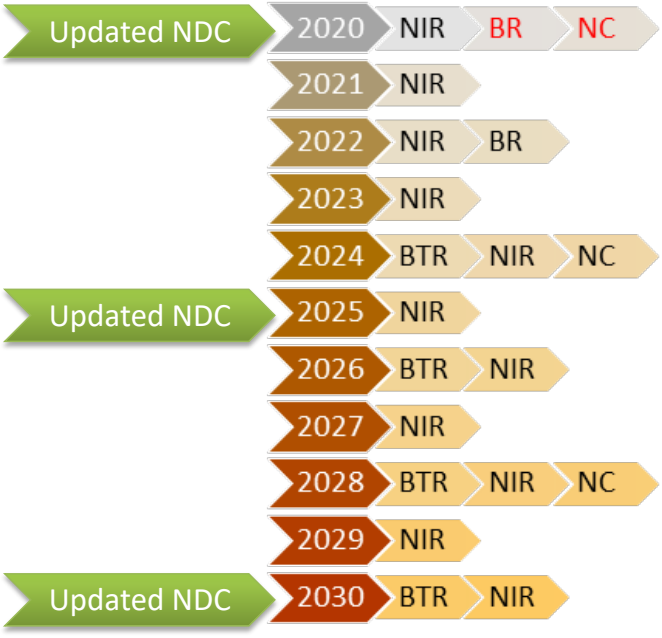


Figure 6.2. Timeline of submissions of the NDC, National Inventory Reports, Biennial Reports, National Communications and Biennial Transparency Reports

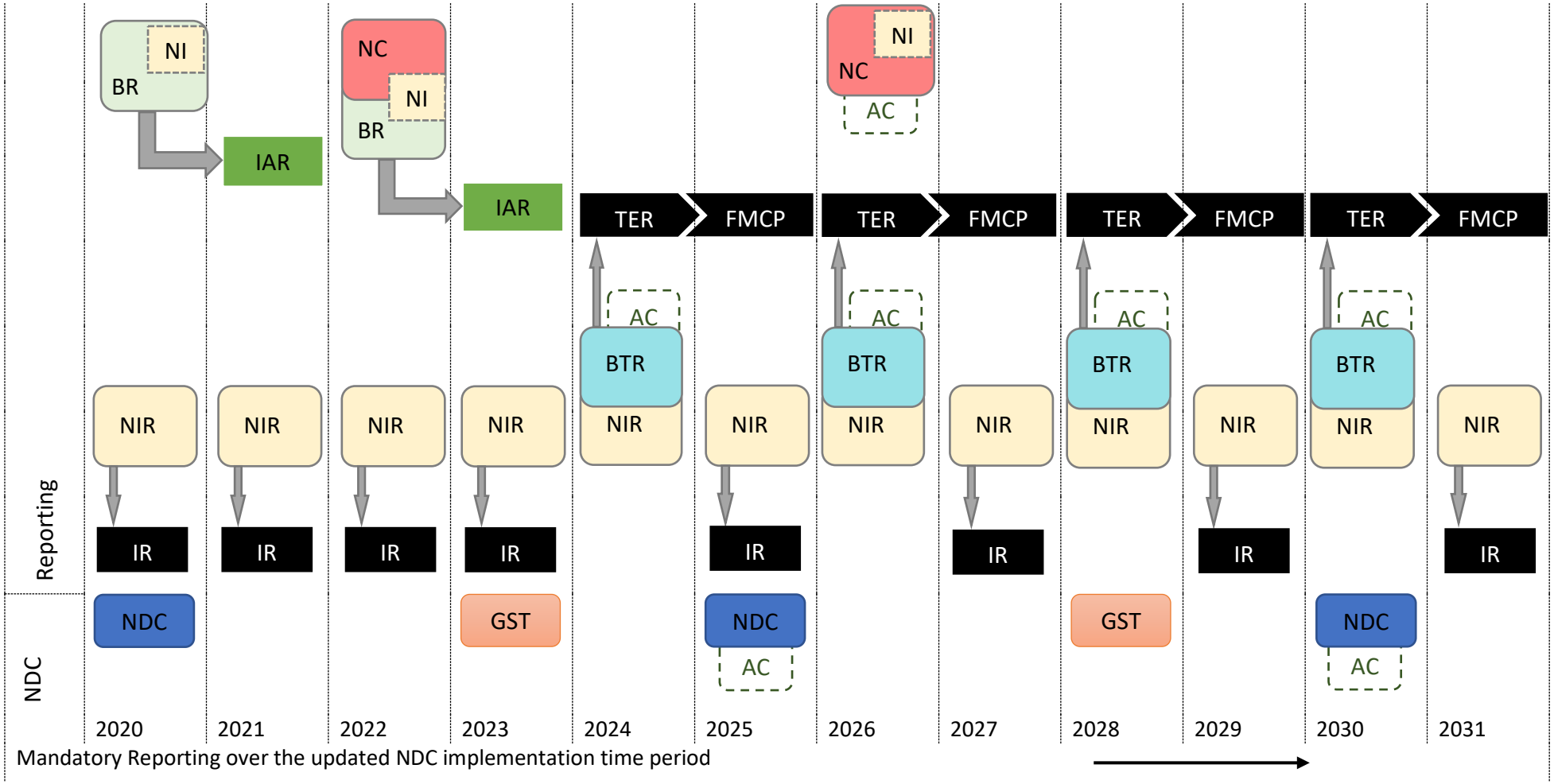


Figure 6.3. Timelines before and after the introduction of the Enhanced Transparency Framework

NC – National Communication, BR – Biennial Report, NI – National Inventory, IAR – International Assessment and Review, TER – Technical Expert Review, FMCP – Facilitative, Multilateral Consideration of Progress, AC – Adaptation Communication, BTR – Biennial Transparency Report, NIR – National Inventory Report, IR – Inventory Review, NDC – Nationally Determined Contribution, GST – Global Stocktake

SECTION 7. CONCLUSIONS

Within the project's scope, a team of international and national experts conducted technical analysis and modelling of the Ukrainian GHG emission pathway scenarios for the updated NDC, and this 36-month-long process was informed by the best international practices and national lessons learned from the first NDC and the development of the Ukrainian 2050 Long-Term Low-Carbon Strategy.

Comprehensive technical analysis of the mitigation and adaptation policy options proposed within the project scope were designed to inform the long-term national sustainable development in pursuit of the net-zero emission goal while addressing the country-specific circumstances for green transformation and recovery and were accompanied by a continuous stakeholder consultation process designed by the project team and conducted in a transparent and inclusive manner in close coordination with the GoU.

As a concluding strategy, the project considers that

(i) the implementation of updated NDC elements, including proposed mitigation and adaptation policies and measures for sustainable economic growth and society transformation,

(ii) the designing of national climate finance approaches and

(iii) the establishment of an enhanced NDC transparency framework

could inform the policy makers, enabling the transformation of the economy and society, increasing private/public companies' and private citizens' acceptance of the urgent necessity for green transformation on the pathway to achieving the Sustainable Development Goals and contributing to the long-term goal of net-zero emissions by 2060 while combating global climate change.

The project's findings and recommendations could be instrumental in transformative economic growth and changes of behaviour patterns in the society considering the existing global challenges of post-COVID-19 green recovery and Ukraine's specific circumstances.

ANNEX 1. DESCRIPTION OF THE MODELS AND TOOLS

TIMES-Ukraine Model

TIMES-Ukraine is a typical linear optimization energy system model of the MARKAL/TIMES family (Loulou et al. 2004), which provides a technology-rich framework for estimating energy dynamics in the long run (Podolets and Diachuk 2011). The Ukrainian energy system in the model is divided into seven sectors: energy supply, electricity and heat generation, industrial users, transport, agriculture, households and services (Figure A.1.1).

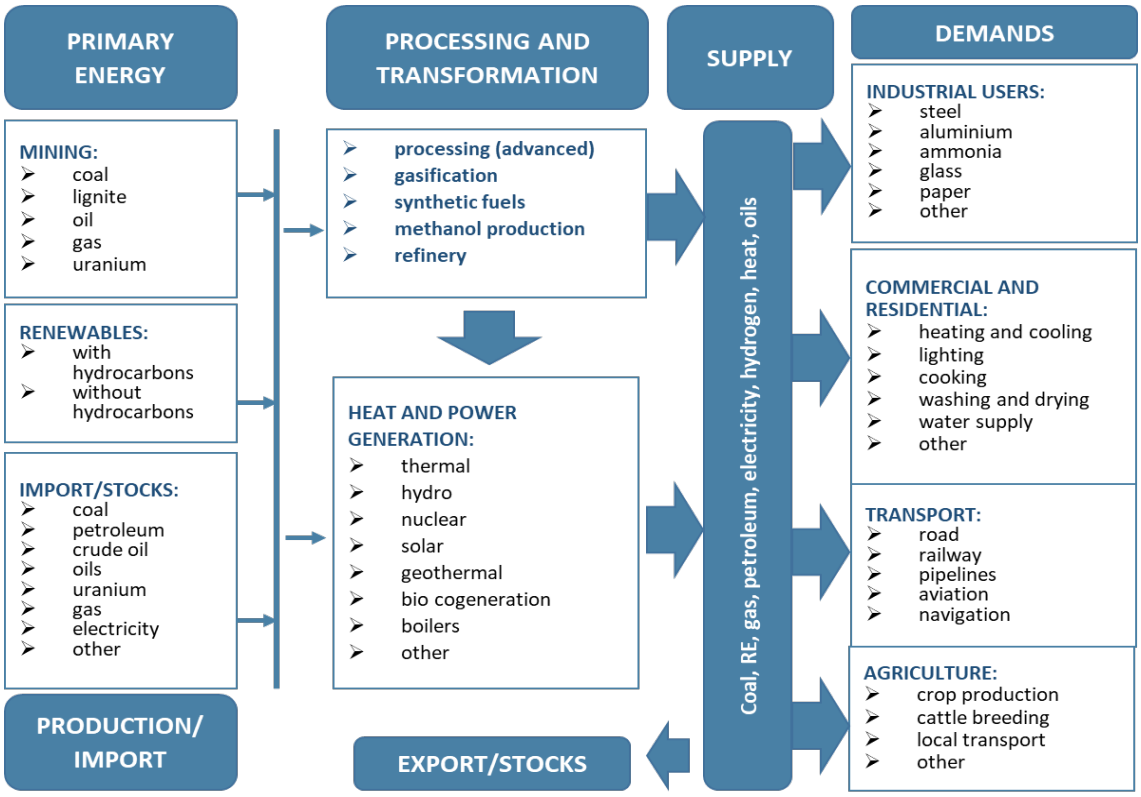


Figure A.1.1. Representation of the energy system in the TIMES-Ukraine model

Industrial users are further disaggregated into two categories depending on their level of energy intensity. Energy-intensive subsectors are represented by product-specific technologies. For other industrial subsectors, we used a standard representation according to the four types of general processes: electric engines, electrochemical processes, thermal processes and other processes. Energy consumption by households and the commercial sector is defined as the most energy-intensive category of consumer needs.

Energy system models, like TIMES-Ukraine, are usually used for the long-term analysis of energy system development paths. By changing the assumptions on useful energy demands, technologies, prices or other exogenous variables, scenarios without measures (baseline scenarios) are developed. In the next step, policy scenarios are designed by imposing additional constraints or targets on the energy system. In this study, we developed one baseline scenario (WOM) and two policy scenarios – with the current measures (WCM) and with additional measures (WAM). For each scenario, the model estimates the least-cost (or maximum-surplus) trajectory of the system, that is, the energy supply and demand by sector and fuel type, energy prices, optimal technology mix and so on. The differences between WOM and policy scenarios are further analysed.

Ukrainian General Equilibrium Model

For the development of the updated NDC, we used a dynamic Ukrainian general equilibrium (UGEM) model to provide an economic assessment of various mitigation strategies. The current version of the model is based on the static model described by Chepeliev (2014), the dynamic mechanisms introduced by the TRPC (2014) as well as the improvements and updates introduced into the model during the current project.

The UGEM model has been widely used in the economic assessment of the various energy and environmental policies in Ukraine. In particular, it was used for the macroeconomic modelling of the carbon taxation and emission trading in Ukraine within the EBRD "Preparedness for Emission Trading in the EBRD Region" (PETER) Project (TRPC 2014). The model was involved in the economic assessment of the Low Emission Development Strategy (LEDS) of Ukraine within the USAID "Municipal Energy Reform Project" (MERP) (USAID MERP 2017). This model was also used for the economic analysis of the different scenarios for the Intended Nationally Determined Contributions (INDCs) for Ukraine within the MERP initiative as well as several other internationally supported projects.

The UGEM model is a single-country recursive dynamic computable general equilibrium model with producers divided into over 89 sectors covering the whole economy. Figure A.1.2 represents the key economic flows in the UGEM model.

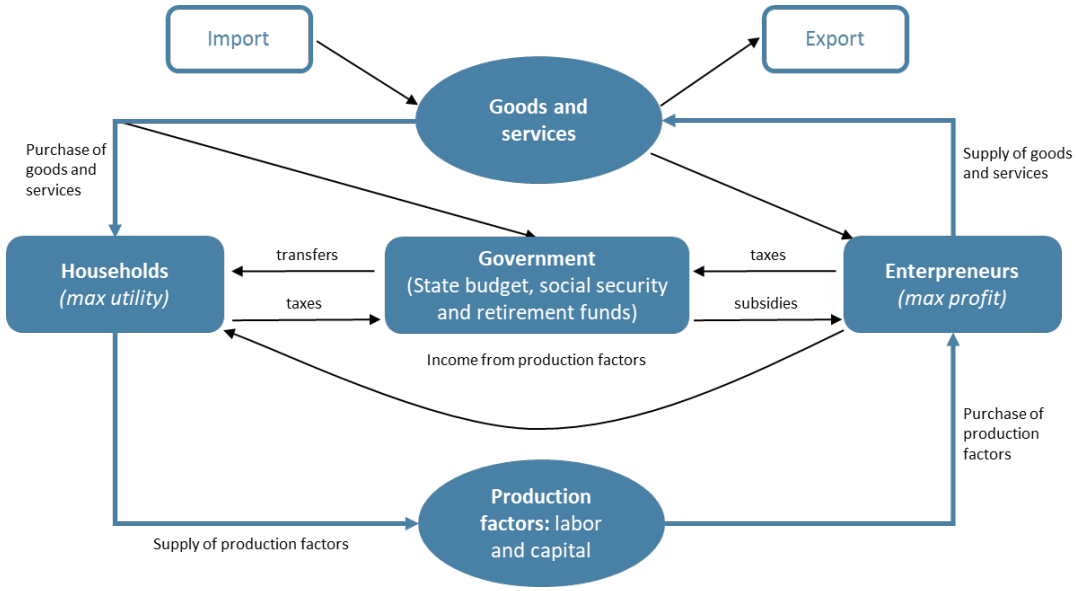


Figure A.1.2. Economic flows in the UGEM model

It is assumed that producers maximize their profits and households maximize their utility. Enterprises produce goods and provide services, using capital, labour and intermediate products. Domestic producers sell their products in the national or international markets. In the domestic market, final goods and services are purchased by households or the government or contribute to the gross capital formation. Households receive labour and capital payments as well as money transfers. The government earns revenue and receives tax payments, providing transfers and subsidies to households and producers. To represent the production and consumption processes in the UGEM model, constant elasticity of substitution[75] (CES) production functions are used. In

[75] Elasticity of substitution indicates the relative changes in consumption quantities resulting from the corresponding relative price changes.

the case of the main production block, a multi-nested CES function is used, which distinguishes energy and non-energy commodities as well as the value-added component.

The UGEM is formulated as a static model and solved sequentially over time. The capital stock is updated in every period based on the capital depreciation rate and investment inflow. The labour supply changes at the same rate as the total population.

The energy sector in the UGEM is represented by seven sub-sectors: coal mining, the extraction of natural gas and oil, coke and oven products, petroleum products, electricity production and distribution, the distribution of natural gas and the heat and hot water supply. Electricity generation is further split into transmission and distribution and seven different generation technologies (coal, gas, nuclear, hydro, wind, solar and other power). Key input data for the model are sourced from the input–output table, household surveys, national accounts, energy balances and international trade statistics. The data inputs are organized in the form of a social accounting matrix based on the 2015 data.

While the UGEM model is able to assess the economy-wide impacts of energy and environmental policies (e.g. emission taxation), it does not represent the energy sector in such a detailed way as the TIMES-Ukraine model. To this extent, an environmental policy analysis can benefit from the linkage of these two models, which we discuss in the next section.

TIMES-Ukraine and UGEM Linkage

To provide a social and economic assessment of NDC scenarios for Ukraine, we used a soft linkage of the TIMES-Ukraine and UGEM models (Figure A.1.3).

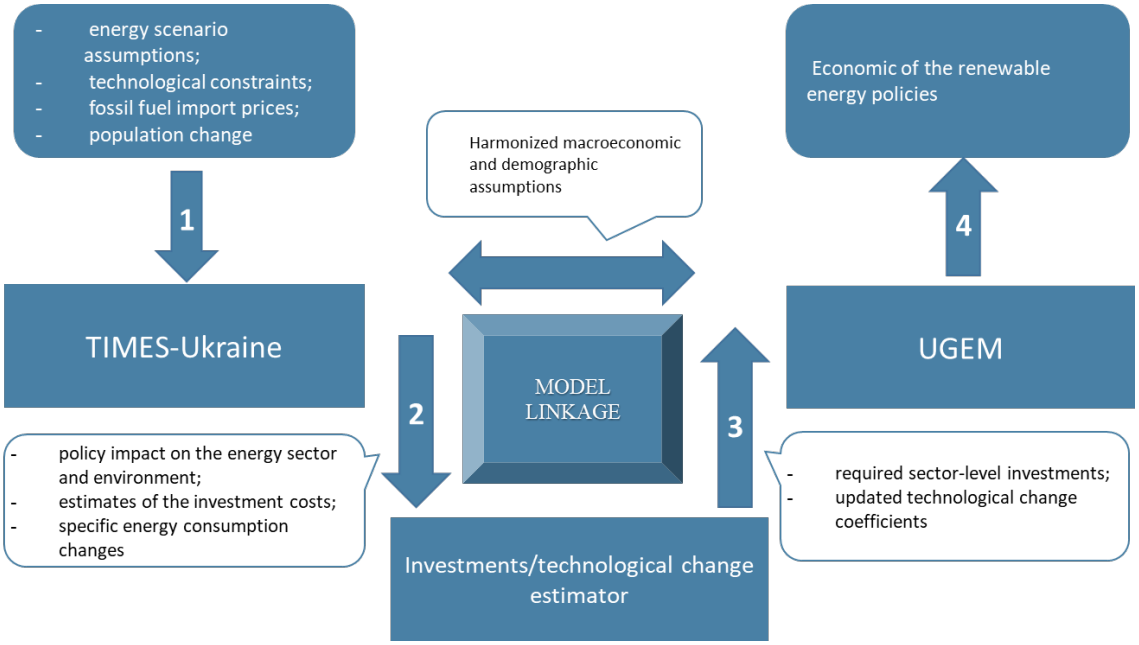


Figure A.1.3. Linkage of the TIMES-Ukraine and UGEM models

First, we calibrated both models to the single set of macroeconomic and demographic assumptions included in the baseline path. In this way, we ensured a harmonized starting point for the model simulations. Second, we provided an assessment of the NDC transition pathway using the TIMES-Ukraine model. In particular, we let the model estimate the most cost-efficient way to achieve this target.

Apart from the energy and environmental effects of such simulation, we estimated the amount of additional investments required to achieve the NDC targets as well as efficiency improvements that follow the implementation of new/better technologies. At this stage, the TIMES-Ukraine model only estimates the costs of such measures and does not provide any information on the funding sources or viability of these policies for the national economy. Therefore, as the third step, we fed the estimated investment costs and sector-specific energy efficiency changes into the UGEM model.

Such an approach is, of course, not without limitations. Under the current set-up, we used only a one-way link – from the TIMES-Ukraine to the UGEM model. In other words, the TIMES-Ukraine simulations served as a source of policy shocks for the UGEM model. A more consistent way of linking the models would include iterative data exchange between models until the outputs of one model match the inputs of the other under the defined level of tolerance. In terms of the policy framework, more attention can be given to the sourcing of additional investments. As noted earlier, we assumed that all the additional costs associated with NDC policy implementation are covered by the internal funds of the energy producers and users; therefore, no external funding is introduced. In this context, it may be worth exploring some alternative assumptions regarding the sourcing of investments. Nevertheless, we consider the approach used in this report to be more inclusive and consistent than the stand-alone use of the two models.

Waste Sector Model

Waste sector modelling was carried out based on the GHG emission estimation methodologies used to compile Ukraine's GHG Inventory, 1990–2017,[76] which was submitted to the UNFCCC Secretariat in 2019. The municipal solid waste (MSW) mass balance model was applied to forecast activity data for solid waste disposal in Ukraine by 2050 by IPCC-specific MSW fractions. For the remaining GHG emission categories of the waste sector, the forecasted activity data was estimated via interrelated equations.

The MSW mass balance model was developed by S. Shmarin in close cooperation with leading national institutions and independent experts in solid waste management issues in 2018. The main provisions of the MSW mass balance model were publicly discussed and published.[77] Schematically, the main principles of the MSW mass balance model are illustrated in Figure A.1.4, showing the following:

- The total amount of MSW generation is equal to the sum of MSW generation covered by the centralized collecting system and the MSW that is not covered.[78] The input data for MSW generation are the population, coverage of the population and MSW generation per capita;
- The MSW generated is split into different waste component flows derived from MSW composition. These flows are paper and cardboard, food waste, garden waste, wood, nappies, rubber and leather, textiles and non-biodegradable items (disaggregated into ferrous metals, non-ferrous metals, glass, plastics, hazardous and other inorganic materials). MSW that is not covered by the centralized collecting system is reallocated to unmanaged shallow dumps;

[76] https://unfccc.int/documents/195605
[77] https://www.dea.edu.ua/img/source/Diser/dis_Shmarin.pdf
[78] Unspecified practices (such as home composting, recycling, etc.) of MSW that are not covered by the centralized collecting system are excluded from the mass balance because they lead to insignificant GHG emissions.

- Food and garden waste components form the raw material flow for composting that is determined by the share of composting practice;
- The glass component forms the raw material flow for reuse, which is determined by the share of reuse;
- Paper, cardboard and non-biodegradable (e.g. plastics, glass and metals) components form the raw material flow for recycling, which is determined by the share of recycling;
- The remaining MSW is divided into two flows – incineration and landfilling – which are determined by the share of incineration;
- The distribution by types of disposal sites is determined by the operationalization of new sanitary landfills.

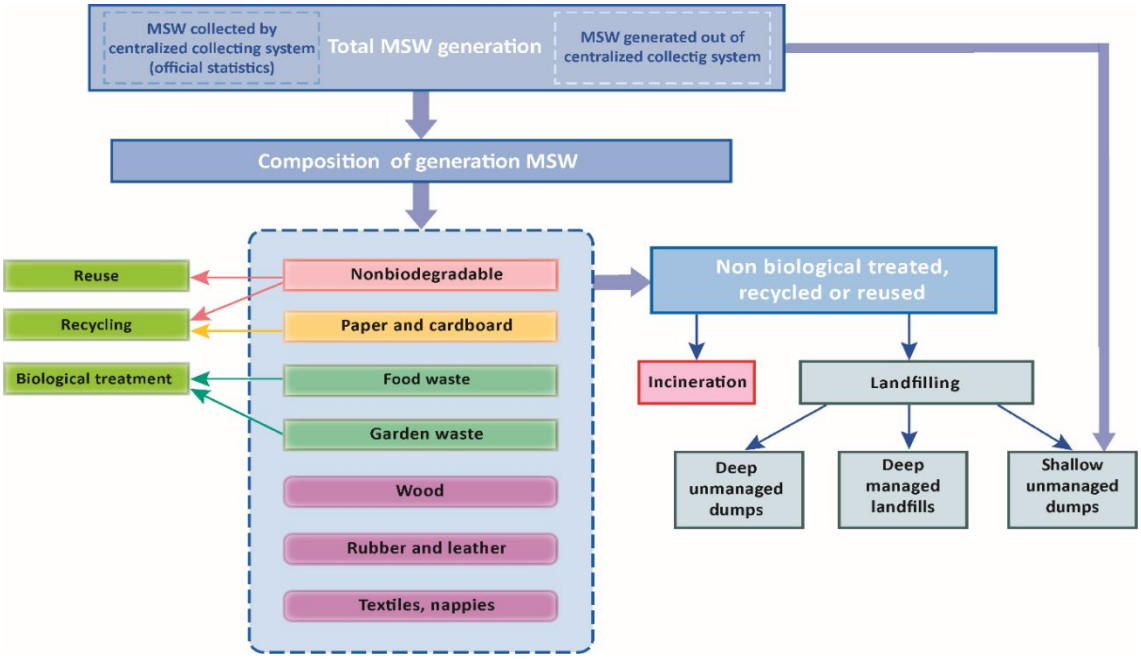


Figure A.1.4. General scheme of the MSW mass balance model (mass flows)

The main advantage of the MSW mass balance model compared with other approaches and methods used to carry out GHG emission projections from solid waste management in Ukraine is as follows. The modelling of MSW management was carried out based on specific MSW categories called fractions (paper and cardboard, food waste, yard waste etc.), wherein the sum of treated fractions is equal to the total amount of MSW generated in Ukraine. Thus, equilibrium was ensured between all the generated MSW and the amount of treated MSW, taking into account the capabilities and exploitation restrictions of the available MSW treatment technologies.

The following indicators and trends were used for GHG emission modelling in the waste sector by categories:

Solid waste disposal: population, MSW per capita generation, waste treatment practice (share of disposal, reuse, recycling, composting, incineration and landfilling), coverage of the population by the centralized waste collecting system, construction of new sanitary (deep managed) landfills, MSW composition and share of landfill methane flaring and recovery.

Biological treatment of solid waste: population, industry and agriculture sector development indicators, MSW per capita generation, share of composting and composting technology.

Incineration and open burning of waste: GDP growth, industry sector development, category-specific legislation (prohibition of MSW incineration without energy recovery).

Wastewater treatment and discharge: population, share of urban and rural inhabitants, sector development indicators (energy, ferrous metallurgy, agriculture, food, etc.), share of wastewater purification and discharge, meat, milk and fruit consumption per capita, technology development, share of wastewater methane flaring and recovery.

The methodological approach applied for conducting projections in the waste sector is in line with the following conditions:

- The key projected indicators and drivers are based on quantitatively determined ones in national waste management programmes and plans;
- The assumptions are in line with the measures and limitations determined by laws and acts;
- The expert judgements are in line with cross-sectoral assumptions, such as energy economic development and energy consumption by sector, demography, etc.;
- Selected indicators for the projections correlate with the activity data and emission factors for historical GHG emission estimation indicated in the IPCC 2006 Guidelines.

The complexity of the applied methodological approach takes into account the following:

- The availability of the projecting indicators and key drivers;
- The amount of GHG emissions in the category and planned development of the activity in the future;
- The best and typical international practice.

Agriculture Model

To build projections of GHG emissions as well as to estimate the possible implications of activities for GHG emission reduction, it is important to maintain methodological consistency between the already-existing methodology and the projections. **According to Ukraine's National Inventory Report submitted in 2018, the GHG inventory in agriculture in Ukraine is based on the methodologies from the 2006 IPCC Guidelines**. Thus, to develop projections for the GHG emission trend, it is important to keep methodological consistency between the calculation methods of the already-existing reporting system and those of future transparency reporting.

The general approach of IPCC methodologies is to multiply activity data (AD) on emission factors (EFs). This has been approved as a simple and effective way of estimating GHG emissions and is widely used under the UNFCCC. It is also suitable for use in projections if a time series of data and factors is available.

Building a set of data and indicators for agriculture in the future offers many advantages. First, it is easy to track the progress in achieving the desired level of emission reduction by reviewing data that are already collected in national statistics. Thus, this will simplify Ukraine's commitment to transparency reporting under the Paris Agreement. In addition, it provides a better understanding of the factors that influence the level of emissions. Therefore, at any stage of the planning or policy-making process in the future, there will be different options available for achieving the GHG emission reduction goal (for example by setting quantitative or qualitative goals). Avoiding overcomplicated projections will also have a positive impact on the stage of public discussions

since the data will be presented in a known and understandable format. Consequently, multilateral considerations will ensure the comprehensiveness of estimations. Lastly, in the case of significant changes in the national inventory system of Ukraine, this approach will allow the estimated level of emissions in the sector to be revised easily.

An alternative way of constructing projections in the sector is to use the historical GHG emission trend to determine possible future emissions. This is an easy and fast method for estimating GHG emissions. However, it has some drawbacks. As reported in Ukraine's NIR submitted in 2018, the historical development of husbandry and crop production in agriculture is uneven in terms of emissions. Since 1990, emissions related to livestock have declined by around 70%, but emissions related to agricultural soils have declined by around 20% and recently this share has been shrinking. Consideration of the general emission trend would lose these national circumstances. That may cause averaging of future development of these sections, which currently have different starting points.

Projecting future emissions based on the general historical level of emissions will also lose details that are very important for policy making, the planning process and the estimation of the effect of these activities. For example, it would be difficult for the Ministry of Agrarian Policy and Food of Ukraine to set clear goals or activities to reduce GHG emissions without an understanding of the main emission sources and ways to affect the emission level.

Land Use, Land Use Change and Forestry (LULUCF) Model

LULUCF in Ukraine is the only sector that removes GHGs. The biggest sink is forests, and a small amount of carbon is removed by grassland. However, there are also sources of emissions. According to Ukraine's NIR submitted in 2018, in this sector, the emissions in the cropland category were higher than those in the agriculture sector in total. Therefore, it is important to keep estimations of GHG emissions and removals in LULUCF separate.

There are different approaches to projecting the development of forestry and corresponding carbon stock changes. Some of them are described in Chapter 1, like those used for constructing the forest management reference level under KP reporting. Ukraine constructed its FMRL until 2020 as well, which is reported in the NIR. To estimate the BAU for forestry until 2020, Ukraine developed its own model using a country-specific methodology. Despite having some drawbacks due to the high level of uncertainty of future forestry measures (the influence of forest cuttings on age structure, wood cutting volumes, natural disturbance events, etc.), this method was recommended by the expert review teams that were reviewing Ukraine's FMRL level[79] and NIR[80] in 2017.

Drawing on the already-existing approach will be beneficial to the construction of the possible contribution of forests to Ukraine's entire NDC since partial data are already available until 2020; these may be analysed and corrected, if needed, and consequently expanded. It also means that already-collected data are available to track the progress of the NDC and to plan measures to increase carbon removal or mitigate emissions. That will also allow methodological consistency to be maintained between the current national inventory system and the projections, which is important for the future reorientation of reporting under the Paris Agreement.

[79] United Nations. 2011. Report of the Technical Assessment of the Forest Management Reference Level Submission of Ukraine Submitted in 2011. https://unfccc.int/sites/default/files/resource/docs/2011/tar/ukr01.pdf
[80] United Nations. 2018. Report on the Individual Review of the Annual Submission of Ukraine Submitted in 2017. https://unfccc.int/sites/default/files/resource/ukr.pdf

Methods for making BAU projections are available as well, as provided in Section 1. Modelling or extrapolating historical GHG emissions or removals in forests is simpler than the abovementioned method, meaning that the calculations require fewer data and resources. This method also mitigates the uncertainties about misevaluations of detailed features, like the age–class structure, the influence of different cuttings on the age structure, changes of species and so on. However, it also loses the advantage of a detailed consideration of forest features, which might change in the future, such as increased wood cuttings due to increased demands for wood, increased frequency and severity of natural disturbances like forest fires, pest and diseases, and changes of afforestation areas.

In 2016–2017, Ukraine received assistance from the EU in its approaches to climate change mitigation and adaptation. This included an expert facility project, "Development of the GHG emissions inventory in the forestry sector in order to improve national reporting of Ukraine according to the requirements of the UNFCCC and the Kyoto Protocol". In this report, the authors suggested the use of a carbon flux model with inputs from GIS. This model was developed by the International Institute for Applied Systems Analysis and allows the inclusion of an assessment of the impact of processes in the ecosystem in general on the carbon budget. This model has the big advantage of including different processes and the estimation of the overall effect without any possible imbalances between pools.

However, its application in Ukraine faces some serious challenges. **The most significant one is data availability.** Despite there currently being different sources of images that can feed into a GIS analysis, no institution in Ukraine is using those images and creating national data for the national inventory system to be used for the GHG inventory in this category. The application of this model without such data is impossible.

Another drawback of such a complex model is **that it is not simple to use when it comes to subjects from different agencies and ministries who are less informed about climate change**. For example, the State Forest Resources Agency of Ukraine, which is responsible for policy making in forestry as well as forest management, will consider planning activities aimed at increasing carbon removal or decreasing emissions. A clear understanding of the factors that influence the level of GHG removal or emissions in forests will provide more options for possible management practices. Moreover, it is even more beneficial to society, which is usually strongly aware of how and why forestry is performed. A good explanation of possible activities and how they are connected to GHG emissions and removal through emission factors will help to inform people better.

The cropland and grassland categories, despite being included in the LULUCF sector, cover agricultural activities on corresponding land. Because of the close interconnections with the agriculture sector, the IPCC consolidated the two sectors into one when it was developing its 2006 Guidelines. However, because UNFCCC reporting counts these sectors separately, it is better to keep them separate in projections as well.

Despite the different sectors, a considerable amount of activity data are used for cropland, grassland and the agriculture sector or some intermediate calculations are used in another sector (like the amount of crop residues, the amount of nitrogen applied with manure or the amount of mineralized carbon in agricultural soils). Thus, for these categories, it is reasonable to keep the same approach as for agriculture – to use the same methodology for the estimation of carbon stock changes as is used currently by Ukraine but project activity data and EFs for the future.

ANNEX 2. UKRAINE'S UPDATED NDC STAKEHOLDER CONSULTATION AND FACILITATIVE DIALOGUE PROCESS

Step 1. Ministry–Project Team's work and high-level consultations

Working-level meetings, consultations and conference calls were held with MinEcology to inform, present, discuss and collect feedback on the modelling and scenario design approach, the updated NDC modelling approaches and results, the combined sensitivity scenario and its modelling results, policies and measures, to discuss and agree on the stakeholder consultation process and to discuss technical issues, the updated NDC process and the inter-ministerial consultation process.

Timeline:

- 19 June and 19 November 2019 – joint Ministry–EBRD Project Team meeting;
- 17 December 2019; 3 February, 7 April, 27 April, 19 May, 23 June, 10 July, 3 August, 8 October, 30 October, 5 November, 22 November, 10 December 2020; 17 February, 24 February, 2 April, 9 April 2021 – Ministry–Project Team coordination conference calls;
- 20 July 2020 – **high-level** introduction meeting with the Minister of Environmental Protection and Natural Resources of Ukraine, Mr Roman Abramovskiy;
- 29 July 2020 – **high-level** consultation meeting with the Vice Prime Minister on European Integration, Ms. Olha Stephanyshyna, the Minister of Environmental Protection and Natural Resources, Mr Roman Abramovskiy, the Deputy Minister of Environmental Protection and Natural Resources, Ms. Iryna Stavchuk, and Vice PM Advisors.

Step 2. Development of the draft Ukraine NDC and continuous facilitative dialogue

A. During the NDC updating Working Group Meeting on Report 3, the Project Team presented the modelling results of all three scenarios, including sensitivity scenarios; members of the WG discussed the modelling results and provided some feedback of a general nature.

Timeline:

- 17 July 2019 – NDC updating Working Group meeting 2
- 14 February 2020 – NDC updating Working Group meeting 3

B. On 10 June 2020, the Ministry Expert Council organized a special meeting on the updated NDC modelling results, at which the Project Team presented the updated NDC modelling results and the stakeholder consultation process to the members of the Ministry Expert Council. As a follow-up of this Expert Council meeting, a technical consultation process was initiated by the Expert Council Working Group on Climate Change and, on 24 June, the first meeting consultation of the Climate Change Working Group took place.

Timeline: 10 June and 24 June 2020

C. As a follow-up of the Expert Council meeting on 10 June 2020, the Ministry and the European Business Association conducted an online EBA Environmental Committee meeting, at which the updated NDC modelling results were discussed on the technical level with private business representatives. Based on the outcomes of this discussion/consultation, the EBA sent an official

EBA position letter with comments and questions on the NDC updating process and results to the Ministry of Energy and Natural Resources, Expert Council and Project Team.

Timeline: 22 June 2020

D. NDC updating Working Group Meeting 4 took place online and aimed to present the updated NDC modelling results and related sectoral policies, measures and SDGs and to collect feedback from broad stakeholders, including members of the NDC updating WG, interested parties from private and public entities, NGOs, academia and over 60 participants who joined the Working Group.

Timeline: 26 November 2020

E. A sectoral stakeholder consultation process was carried out to present sector-specific policies and measures in online sessions of 1–1.5 hours on energy policies and measures, waste sector policies and measures, transport policies and measures, agriculture policies and measures, forestry policies and measures and industry policies and measures with the relevant responsible ministries, state authorities and other interested stakeholders to provide clarification and collect their feedback (over 200 participants contributed to the process).

Timeline: December 2020–May 2021

List of stakeholders consulted on policies and measures

1. Ministry of Environmental Protection and Natural Resources
2. Ministry of Development of Economy, Trade and Agriculture
3. Ministry of Communities and Territories Development
4. Ministry of Infrastructure
5. Ministry of Energy
6. Ministry of Strategic Industry Development
7. Ministry of Foreign Affairs
8. Ministry of Finance
9. Ukraine's National Bank
10. Ministry of Health
11. Verkhovna Rada of Ukraine and its relevant committees (environmental, energy, economy, finance and others)
12. State Forestry Agency
13. State Water Agency
14. State Energy Efficiency Agency
15. National Regulatory Commission on Energy and Utilities
16. Office of the President
17. Prime Minister's Office
18. Vice Prime Minister of the European Integration Office
19. Cabinet of Ministers Secretariat Governmental Office for Coordination of European and Euro Atlantic Integration
20. Local and regional state authorities

Private and Public Businesses

1. UkrEnergo
2. CentrEnergo
3. Naftogas
4. Ukraine Coal (state company)
5. EnergoAtom
6. DTEK
7. MetInvest
8. ArcelorMittal

NGOs and Professional Industrial and Business Associations

1. Biofuel Association
2. Wind Power Association
3. Renewable Energy Association
4. Trade and Industry Chamber of Commerce
5. Iron and Steel Association
6. Cement Association
7. Agricultural Confederation
8. Other interested industry/sectoral associations
9. Civil Rada of Ministry of Environmental Protection and Natural Resources
10. NECU (Ecodiya, 350.org, Eco-club and others)
11. European Business Association

International Donors/Organizations

1. World Bank
2. IFC
3. EIB
4. EBRD
5. NEFCO
6. IMF
7. GIZ/BMU
8. Energy Community Office
9. EU Delegation Office and Ukraine Support Team
10. Covenant of mayors
11. FAO
12. EU4ENERGY
13. EU4CLIMATE
14. EU4ENVIRONMENT
15. Ukraine–Denmark Energy Centre

Not all the above-listed stakeholders were involved in the consultation process, while key stakeholders were engaged and informed by the GoU.

Step 3. Development of supporting and background documents

Formal supporting documents for the GoU decree "National Ukrainian NDC" were drafted and developed (Explanatory Note, Political Note, Regulatory Impact Note and others in accordance with and in the format required by the Cabinet of Ministers' Regulations).

Timeline: January–June 2021

Step 4. Formal public stakeholder consultation process

The Ministry of Environmental Protection and Natural Resources of Ukraine formulated the updated NDC target and placed the draft GoU decree on its official website for a 30-day formal public consultation process and then conducted a formal public consultation meeting with the Civil Rada of the Ministry.

Timeline: 1 April–1 May 2021

Step 5. Formal concurrence process with ministries, state authorities and agencies

The Ministry of Environmental Protection and Natural Resources of Ukraine submitted the draft governmental decree on "Updated Ukrainian NDC", including supporting documents, as per Step 3 for comments and concurrence to all the relevant state authorities, ministries and agencies at the end of March 2021. Once the process of concurrence had been finalized, the Ministry developed a comparison table and other supporting documents based on formal written comments and as result of formal consultations with relevant ministries and state agencies.

Timeline: April–June 2021

Step 6. Inter-ministerial Commission on UNFCCC implementation meeting

The Minister was recommended to call a regular meeting of the Commission to present the draft updated Ukrainian NDC target for discussion. The expected outcome was the recommendation by the Commission to the Minister of Ukraine's NDC target. However, the GoU selected a different high-level consultation path, and the Inter-ministerial Commission on UNFCCC Implementation has not met.

Step 7. Updated Ukrainian NDC was adopted by the Cabinet of Ministers of Ukraine and submitted to the UNFCCC in July 2021

Timeline: 31 July 2021