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UKRAINIAN CLIMATE OFFICE

SUPPORTING AN AMBITIOUS CARBON TAX REFORM IN UKRAINE

December 2025

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Executive summary

- Ukraine's current carbon tax is too low and narrow in scope to incentivise meaningful decarbonisation. Reform is urgently needed to **align with EU climate policy, prepare for integration with the EU ETS2**, and avoid increasing costs under the EU Carbon Border Adjustment Mechanism (CBAM).
- Modelling results show that an ambitious reform, moving to an upstream, fuel-based carbon tax in line with Ukraine's National Revenue Strategy, with a gradually rising tax rate converging towards EU ETS2 levels, could **reduce emissions by up to 50%** relative to baseline levels by 2035, while generating **fiscal revenues of up to 4.7% of GDP**.
- **Macroeconomic impacts are modest, but tangible**. GDP and welfare growth decline slightly relative to baseline (-0.2 to -0.4 percentage points per year), while long-term competitiveness could improve through accelerated investment in renewables, electrification, and efficiency.
- **Sectoral impacts are uneven**. Renewable electricity is the main beneficiary, with output more than doubling by 2035, while fossil-based generation and energy-intensive industries face structural adjustment pressures. Complementary industrial and just transition policies are needed to manage these shifts.
- Distributional analysis confirms the **regressive nature of carbon taxation**. Energy poverty risks increase, especially for low-income households, who face rising shares of income spent on energy. Without **targeted support**, vulnerable groups may be disproportionately affected.
- **Revenue recycling** is the decisive factor for success. With potential revenues in the range of several percent of GDP, Ukraine has the fiscal space to:
    - **Fund targeted social compensation** (e.g. through direct transfers, climate dividends, or expansion of the Housing and Utilities Subsidy scheme).
    - **Support energy efficiency and electrification** measures that reduce long-term energy costs for households and businesses.
    - **Attract EU co-financing for decarbonisation investments**, such as via a reformed Decarbonisation and Energy-Efficient Transformation Fund with shared Ukraine-EU governance, modelled after Ukraine's Energy Efficiency Fund.
    - **Invest strategically in district heating modernisation**, renewable energy, public transport, and low-carbon industrial transformation.
- **Transparent, predictable, and well-communicated use of revenues** is critical to public trust. International experience (e.g. EU ETS earmarking rules, Nordic carbon tax models) shows that visible reinvestment into households and infrastructure underpins both political acceptability and environmental effectiveness.
- **A phased reform path**, supported by strong monitoring, verification, and alignment with the upcoming Ukrainian ETS, is essential to avoid shocks, provide investment certainty, and ensure a level playing field across sectors.
- Overall, a reformed carbon tax can be a **cornerstone of Ukraine's low-carbon transition and EU accession process** — delivering emissions reductions, fiscal

resilience, and strategic alignment with EU climate architecture, provided it is accompanied by robust social safeguards and reinvestment mechanisms.

Content

1. Context and motivation

Ukraine currently has an environmental tax on CO_2 emissions, with a very low tax rate of 30 UAH/tCO_2 (or about 0.82 EUR/tCO_2) at the time of writing – insufficient for stimulating any meaningful emissions reductions. It is a downstream tax levied on stationary installations emitting more than 500 tCO_2 per year.[1] The tax is largely based on the self-reporting of emissions, which allowed for widespread tax avoidance in the past.[2]

As part of the Ukraine-EU Association Agreement, which entered into force in 2017, Ukraine has committed to introducing an ETS. This process has gained momentum with Ukraine's official EU accession candidate status in 2022 and the subsequent opening of accession negotiations in 2024. In October 2024, Ukraine adopted the Law on the Basic Principles of State Climate Policy which enshrines the environmental tax and the emissions trading system as cornerstone fiscal and market instruments to incentivise greenhouse gas emissions reductions. In early 2025, Ukraine's Cabinet of Ministers has adopted an action plan for establishing a national greenhouse gas emissions trading system. While the action plan leaves open the design of the ETS – including methods for cap setting, allowance allocation, etc. – it mandates the launch of the first phase of the ETS in 2028.[3]

Due to the large war-induced uncertainty, setting a fixed cap during the first ETS phase without additional price support instruments would render carbon price outcomes highly unpredictable. This problem could be addressed by introducing transitional fixed allowance prices during the first phase or a price collar with a rising floor to provide price certainty.[4] In this regard, the action plan explicitly mentions that mechanisms for market stability should be explored. A gradual phase-in of surrendering obligations following the model of the EU ETS expansion to maritime transport is also being discussed.

While the specifics of the upcoming national ETS are still under consideration, the scope will likely include stationary installations with a total rated thermal input exceeding 20 MW, following the EU ETS1. This would result in a large overlap in scope with the current environmental tax on CO_2 emissions, although the latter also covers smaller installations if they emit more than 500 tCO_2 per year. Therefore, the carbon tax would require reform before the introduction of the national ETS to avoid pricing the same CO_2 emissions twice.

At the same time, this creates an opportunity for transforming the carbon tax from an ineffective and irrelevant tax to a transformational instrument for decarbonisation and a powerful complementary policy to Ukraine's planned national ETS. In the long term, Ukraine aims to join the EU ETS, comprising the ETS1 and ETS2, upon EU accession. While the national ETS serves as a precursor

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[1] Tax Code of Ukraine, Article 240

[2] Romanko, S. (2018). Carbon Tax Perspectives in Ukraine: Legal Regulation and Comparison of the National and European Experience of Implementation. *Journal of Vasyl Stefanyk Precarpathian National University, 5*(2), pp. 137-144.

[3] A second phase is foreseen not earlier than three years from the date of the end of martial law in Ukraine.

[4] Stubbe, R. et al. (2024). *Designing a suitable Emissions Trading System for Ukraine. Squaring EU convergence, price certainty and competitiveness*. Low Carbon Ukraine Policy Proposal. (Link)

to the ETS1, Ukraine currently has no plans for carbon pricing in the ETS2 sectors (road transport, buildings and additional sectors). An expansion of the carbon tax to the ETS2 sectors therefore seems like a logical step. A number of EU Member States have followed this approach and introduced carbon taxes covering these sectors, some of which have explicitly designed their national carbon taxes in line with the ETS2 scope and a price path towards expected ETS2 prices to provide for a smooth transition to the new scheme. By following a similar approach and covering these sectors with a continuously increasing tax rate gradually approaching expected ETS2 price levels, Ukraine's reformed carbon tax could be aligned with the scope of the EU ETS2, closely following the activities outlined in Annex III to the EU's ETS Directive.[5] Such a proactive approach could showcase Ukraine's commitment for early transposition of climate acquis during EU accession negotiations.

Finally, a transition to an upstream carbon tax following the scope of the ETS2 would also implement a key proposition of Ukraine's National Revenue Strategy. The National Revenue Strategy notes that the current environmental tax on CO_2 emissions likely does not comply with OECD principles and explicitly proposes to assess "the possibilities of ensuring the transition from the environmental taxation of actual carbon dioxide emissions to the taxation of fossil fuel [...] depending on the carbon dioxide content."[6] A move to an upstream tax, taxing the carbon content of fossil fuels when released for consumption, could significantly reduce the administrative burden of the tax, since retailers are less numerous than final consumers (such as downstream installations). This also reduces the risk of tax evasion. In principle, the upstream carbon tax could be layered on the existing excise tax or introduced as a separate tax on embedded emissions in fossil fuels.

Against this backdrop, this study analyses how Ukraine's carbon tax can be reformed into an ambitious and forward-looking instrument that both avoids overlap with the upcoming national ETS and prepares the ground for integration into the EU ETS. Based on a thorough review of carbon pricing models used in EU Member States, the study proposes reforming Ukraine's current system by shifting to an ambitious upstream, fuel-based carbon tax with expanded scope and a price path converging to EU ETS2 levels. This is followed by a detailed, model-based assessment of the macroeconomic and distributional impacts of the proposed reform using different design and price path scenarios.

[5] European Commission (2024). Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC. (Link)

[6] Cabinet of Ministers of Ukraine (2023). National Revenue Strategy until 2030. (Link to unofficial translation)

2. Review of carbon taxation models in EU member states and their role in the EU climate architecture

2.1 EU climate architecture

The main instrument for incentivising emissions reductions in the European Union since 2005 has been the **EU Emissions Trading System** (EU ETS, or **ETS1** for differentiation). The ETS1 is a cap-and-trade system covering large stationary energy and industrial installations, aviation (since 2012) and maritime transport (since 2024) in all EU Member States, EFTA countries[7] and Northern Ireland (for electricity generation only) and is linked with the Swiss ETS since 2020. The ETS1 accounts for approximately 40% of all GHG emissions in the European Union.[8] Its cap is reduced annually in line with the EU's climate targets and will reach near-zero emissions by 2039.

The **Effort Sharing Regulation (ESR)** introduced binding national targets for EU Member States for emissions outside the ETS1 for the years 2021-2030. It includes domestic transport (excl. aviation), buildings, small industry, agriculture and waste, accounting for almost 60% of domestic EU emissions. Not covered are emissions from land use, land use change and forestry (LULUCF) for which a separate Regulation with national targets exists. National emissions reduction targets under the ESR recognise the different capacities of Member States by differentiating targets according to GDP per capita. Overall reduction targets for the ESR sectors amount to -40% by 2030 (vs. 2005) across the EU. Together with higher ambitions in ETS1 sectors, this is in line with the EU's cross-sectoral -55% (vs. 1990) emissions reduction target for 2030.

Member States are free to design **national policies** for achieving their emissions reduction targets under the ESR. Many Member States have introduced **carbon taxes** covering some or all sectors subject to the ESR. Recognising the efficiency gains from a harmonised carbon pricing scheme, the EU is introducing a second ETS (**ETS2**) for road transport, buildings and small industry by 2027 which will coexist with the ESR. Some Member States have explicitly designed their national carbon taxes in line with the ETS2 scope and a price path towards expected ETS2 prices to provide for a smooth transition to the new scheme. Whether the ESR approach will still be applied after 2030 is currently unclear as most ESR emissions will be covered by the ETS2 from 2027 onwards. There are also discussions for introducing a third ETS (ETS3) for agriculture in the future.[9]

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[7] Iceland, Liechtenstein, and Norway

[8] European Commission (n.d.) About the EU ETS. (Link)

[9] Trinomics (2023). Pricing Agricultural Emissions and Rewarding Climate Action in the Agri-food Value Chain. Trinomics study for the European Commission, DG CLIMA. (Link) ; Furthermore, the European Commission also assesses a proposal to extend the ETS1 to municipal waste incineration by 2028, see European Parliament (2023). *Review of the EU ETS 'Fit for 55' package*. BRIEFING EU Legislation in Progress. (Link)

Complementary policies to the ETS1, ESR and upcoming ETS2 include renewable energy support schemes in Member States, policies mandating energy efficiency in buildings such as the Energy Performance of Buildings Directive (EPBD), national policies supporting investments in energy efficient thermal renovations, heat pumps and other clean heating technologies, the EU CO_2 emission performance standards for new passenger cars and vans, as well as national support schemes for electric vehicles and taxation of emissions-intensive vehicles in some Member States.

In parallel to the EU ETS, Directive 2003/96/EC (the Energy Taxation Directive) sets minimum excise duty rates for energy products and electricity across all EU Member States.[10] While not a carbon pricing instrument per se, it establishes a baseline level of fuel taxation that indirectly embeds a carbon signal into energy prices. However, in most Member States, excise taxes are primarily a fiscal instrument, providing stable revenues, e.g. for road maintenance, and addressing other externalities (road damage, congestion, accidents, local air pollution). The Directive allows numerous exemptions and reduced rates, e.g. lower taxes on commercial diesel, tax breaks for renewable energy and public transport fuels, and relief for energy-intensive industries. As Ukraine aligns with EU acquis, this Directive becomes relevant: the carbon content of fuels subject to excise taxes must be accounted for, and a carbon tax reform must avoid undermining these minimum rates.

2.2 Review of carbon taxation models in EU Member States

Carbon taxes have historically **complemented the EU ETS** by pricing emissions outside the scope of the ETS1, to meet national targets under the ESR, tackling emissions in buildings, road transport, small industry, agriculture, and waste. Unlike a cap-and-trade scheme, a tax sets a **predictable price** on emissions and can be layered on existing fuel excises or created as a stand-alone levy. These taxes vary widely in their legal basis and design across Member States (see Table A1 in the Annex). Sweden's upstream carbon tax, in place since 1991 and indexed to inflation since 1994, has risen steadily to exceed the equivalent of 100 EUR/tCO_2, demonstrating both durability and predictability over time. Ireland's excise-based carbon charge, introduced in 2010, sets out annual increases in legislation with the goal of reaching 100 EUR/tCO_2 by 2030. Both models steer households and firms in non-ETS sectors toward efficiency and lower-carbon options with clear forward price signals.[11]

Such experience of EU Member States can help Ukraine to: (i) avoid double charging between a reformed carbon tax and the upcoming national ETS, (ii) cover ETS2 sectors effectively ahead of accession, and (iii) phase-in carbon prices gradually converging toward EU levels without major shocks.

[10] European Commission. (2016). EU rules for the taxation of energy products and electricity. (Link)

[11] Government Offices of Sweden, Ministry of Finance (2022). Carbon taxation in Sweden – general info. (Link); Government Offices of Sweden (2025). Sweden's carbon tax. (Link); Irish Department of Finance (2010). Finance (No. 2) Act 2010. (Link); Irish Department of Finance (2020). Finance Act 2020. (Link)

2.3 Design choices and trade-offs

Design choices and trade-offs in the implementation of carbon taxes across EU Member States can be understood by examining comparative international data.[12] National systems differ along several dimensions (see Table A1 in the Annex for details).

Legal basis

Member States either legislate stand-alone carbon-pricing acts (e.g., Sweden; Denmark's law for a CO_2e tax on ETS sectors) or embed a carbon component in fuel excise legislation (France, Ireland, Portugal). The legal route affects visibility, amendment mechanics and coordination with other fiscal instruments.[13]

Point of taxation and obligation

In most countries, carbon taxes are levied upstream at the point where fuels are released for consumption, a design that is administratively straightforward and ensures broad coverage. Some systems, however, apply the charge downstream at the level of individual installations, as in Estonia's Environmental Charges Act, which targets stationary emitters outside the EU ETS.[14]

Tax base

The dominant approach is fuel-based taxation (Sweden, Ireland, Luxembourg). Others tax direct emissions from installations (Latvia, Denmark). The Netherlands operates an effective hybrid: a levy on verified emissions with an explicit ETS offset, creating a national price floor without double pricing.[15]

Interaction with the EU ETS (avoiding double pricing)

Two approaches are widely used:

- A tax exemption or relief for EU-ETS installations for fuels used within the ETS1 boundary (Sweden, Ireland). Latvia's law excludes EU-ETS-covered operations from its CO_2 charge.[16]

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[12] World Bank. (2025). *Carbon Pricing Dashboard — Data (Excel)*. Washington, DC: World Bank. (Link)

[13] Government Offices of Sweden, Ministry of Finance (2022). *Carbon taxation in Sweden – general info.* (Link); Irish Department of Finance (2010). *Finance (No. 2) Act 2010.* (Link); Republique française (2020). Decree *No. 2020-456 of 21 April 2020 on the Multi-annual Energy Programme (PPE 2019–2028).* Légifrance. (Link); Connaissance des Énergies (n.d.). *Quel est le montant de la 'taxe carbone' en France?* (Link); Folketinget (2024). *L 182: Act on a tax on CO_2e emissions from quota-regulated sectors.* (Link); Danish Ministry of Taxation (2024). *L 182 factsheet.* (Link); Diário da República (2014). *Law 82-D/2014 (Green Tax Reform).* (Link); Diário da República (2017). *Portaria 384/2017 (CO_2 add-on; Art. 92-A CIEC).* (Link)

[14] Government Offices of Sweden, Ministry of Finance (2022). *Carbon taxation in Sweden – general info.* (Link); Estonia (2014). Environmental Charges Act (English overview). (Link)

[15] Government Offices of Sweden, Ministry of Finance (2022). *Carbon taxation in Sweden – general info.* (Link); Irish Department of Finance (2010). *Finance (No. 2) Act 2010.* (Link); Government of Luxembourg (2024). *National Energy and Climate Plan (PNEC).* (Link); Republic of Latvia (2016). *Natural Resources Tax Law (English).* FAOLEX consolidated text. (Link); Netherlands Emissions Authority (NEa) (n.d.). *Tarieven CO_2-heffing.* (Link); Netherlands (n.d.). *Wet belastingen op milieugrondslag (industrial CO_2 levy chapter).* (Link); Folketinget (2024). *L 182: Act on a tax on CO_2e emissions from quota-regulated sectors.* (Link)

[16] Government Offices of Sweden, Ministry of Finance (2022). *Carbon taxation in Sweden – general info.* (Link); Irish Department of Finance (2010). *Finance (No. 2) Act 2010.* (Link); Republic of Latvia (2016). *Natural Resources Tax Law (English).* FAOLEX consolidated text. (Link)

- Credit the ETS price against a domestic levy so firms pay only the difference. The Netherlands' levy works this way: in 2025, the national tariff of 87.90 EUR/tCO_2 minus an ETS price of 66.76 EUR/tCO_2 yields a 21.14 EUR/tCO_2 net levy; if ETS exceeds the tariff, the levy falls to zero.[17]

Price path

Predictability underpins investment. Ireland's statute sets steps to 100 EUR/tCO_2 by 2030; Austria's NEHG fixes prices through 2025 before auctioning; the Netherlands publishes a schedule rising to 152.10 EUR/tCO_2 by 2030. By contrast, France's planned path was frozen at 44.6 EUR/tCO_2 after 2018, weakening credibility.[18]

Revenue recycling

Practices range from general-budget treatment (Sweden, Portugal) to targeted social and climate spending (Luxembourg, Germany). Latvia channels receipts to state and environmental budgets, with shares set in fiscal laws and adjusted over time rather than fixed permanently. Transparent use supports acceptance and complementary investments.[19]

Coverage

Sweden approaches economy-wide coverage with reliefs where ETS applies; many others focus on transport and buildings via fuel excises. Administrative capacity and legacy tax systems often drive these choices.

2.4 Political and economic drivers in the carbon tax design

Several factors explain the diversity of carbon tax models:

- Economic structure. Countries with carbon intensive industry fear competitiveness impacts. Denmark's levy differentiates rates for

[17] Netherlands Emissions Authority (NEa) (n.d.). *Tarieven CO_2-heffing.* (Link); Netherlands (n.d.). *Wet belastingen op milieugrondslag (industrial CO_2 levy chapter).* (Link); Netherlands Emissions Authority (NEa) (n.d.). *Afvalverbrandingsinstallaties (inclusion of waste incineration).* (Link); Also compare with Chapter 2.3 in Stubbe, R. (2025). *Pathways for reforming Ukraine's carbon tax. Towards an ETS-compatible upstream tax with an expanded scope*. Low Carbon Ukraine Policy Proposal. (Link)

[18] Irish Parliamentary Budget Office (2024). *Carbon Tax Series: Part 1 – What is the carbon tax?.* (Link); Austria – Federal Ministry of Finance (2022). *Initial information on the National Emissions Certificates Trading Law (NEHG 2022).* (Link); Netherlands Emissions Authority (NEa) (n.d.). *Tarieven CO_2-heffing.* (Link); Republique française (2020). *Decree No. 2020-456 of 21 April 2020 on the Multi-annual Energy Programme (PPE 2019–2028).* Légifrance. (Link); Connaissance des Énergies (n.d.). *Quel est le montant de la 'taxe carbone' en France?* (Link)

[19] Government Offices of Sweden, Ministry of Finance (2022). *Carbon taxation in Sweden – general info.* (Link); Diário da República (2014). *Law 82-D/2014 (Green Tax Reform).* (Link); Government of Luxembourg (2024). *National Energy and Climate Plan (PNEC).* (Link); Government of Luxembourg (2021). *National Reform Programme 2021.* (Link); Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU) (2019; amended). *Fuel Emissions Trading Act (BEHG) – English translation.* (Link); German Federal Government (2020). *National emissions trading (nEHS).* (Link); Republic of Latvia (2016). *Natural Resources Tax Law (English).* FAOLEX consolidated text. (Link)

mineralogical processes, while Ireland provides reliefs for agriculture and horticulture.

- **Administrative capacity.** Upstream fuel taxes require less monitoring than downstream emissions-based taxes. Sweden and Ireland chose upstream designs to minimise administrative burden, whereas Latvia and Denmark use emissions-based levies where MRV systems are available.
- **Public acceptance.** Political backlash can derail ambitious trajectories. France's aborted tax increases after the "gilets jaunes" protests highlight the need for social compensation and clear communication. Luxembourg mitigates opposition by earmarking revenues for climate measures and cost of living allowances.
- **Policy integration.** Some governments view carbon taxes as a temporary bridge to ETS2. Germany and Austria introduced national emissions trading systems with fixed price phases that will transition into EU-wide trading. The Netherlands' top up tax is explicitly designed to guarantee a minimum carbon price until EU allowance prices rise above national levels.

2.5 Lessons learned

Best-practice elements observed across EU Member States show that **predictable and transparent price signals are essential** for credibility and investor certainty. **Clear, legislated price trajectories** (such as Ireland's pathway to 100 EUR/tCO2 by 2030) provide a stable framework for planning, while **indexation to inflation**, as applied in Sweden, ensures that the real value of the carbon price is maintained over time. Equally important is **transparent revenue recycling**, with several Member States directing carbon-tax proceeds **towards climate action and social support measures**, as in Luxembourg and Germany. Another key design feature concerns the **interaction between national carbon taxes and the EU ETS**: mechanisms **to avoid double taxation**, including exemptions for ETS-covered installations or offsetting the domestic tax by the prevailing allowance price, as practised in Latvia and the Netherlands, ensure policy coherence and prevent overlapping price signals.[20]

Experience also highlights **several common pitfalls that should be avoided**. **Freezing planned carbon-price increases in response to political pressure**, as occurred in France after 2018, undermines policy credibility and weakens the long-term signal. **Setting carbon prices at very low and static levels** results in limited behavioural change and minimal emissions abatement. Furthermore, **excessive complexity in the form of multiple exemptions or differentiated rates** increases administrative burden and reduces the clarity of incentives; Denmark's differentiated mineralogical rate illustrates how efforts to address specific leakage risks can also introduce design complications.

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[20] Coordination should also be ensured between existing fuel excise duties (minimum fuel excise tax rates according to the Energy Taxation Directive) and the carbon tax, whether implemented as a separate tax or as an additional component to the fuel excise tax. We argue that Ukraine's reformed upstream carbon tax should come on top of the existing minimum fuel excise tax rates which primarily address other externalities (road damage, congestion, accidents, local air pollution) while the carbon tax aims to address the external costs of greenhouse gas emissions.

Overall, **durable and credible EU carbon tax regimes** tend to share several **core characteristics**: they rely on an **upstream, fuel-based design** covering sectors similar to those included in the upcoming ETS2; they adopt **transparent, multi-year price paths or indexation mechanisms**; they establish **clear rules for interaction with the EU ETS** to avoid double pricing; and they ensure that **revenue use** is **well communicated** and **directed towards social protection and decarbonisation investment**.

3. A proposal for an ambitious reform of Ukraine's carbon tax

Building on the comparison of EU carbon tax systems and the accompanying best-practice analysis, a reformed carbon tax in Ukraine should ideally be designed to fulfil the following criteria:

- **Provide investor certainty** across sectors to increase incentives for investments in decarbonisation measures in renewable energy, batteries, heat pumps, EVs, etc.
- **Align with EU developments** to effectively cover the sectors within the scope of the EU ETS2 (buildings, road transport and small industry) and prepare them for EU accession
- **Avoid a double price burden** between the carbon tax and the upcoming national ETS, while potentially serving as a bridge to temporarily cover all sectors before the first phase of the ETS
- **Gradually converge to expected EU ETS2 prices**, within an appropriate timeline [21] and price path
- **Reduce CBAM adjustment costs** for exports to the EU, retaining carbon pricing revenues in Ukraine

These criteria can be fulfilled with an upstream carbon tax, either layered on existing excise taxes or a standalone upstream carbon tax covering the activities outlined in Annex III to the EU's ETS Directive.

Optionally, the scope of the tax could also include the activities covered by the upcoming ETS, either temporarily until the first phase of the ETS or potentially beyond, if a tax deduction or rebate rule ensures that the effective carbon price from the ETS is deducted from the tax burden. The latter approach, following the example of the Dutch carbon tax and the UK carbon price floor, could effectively establish a price floor for the sectors covered by the upcoming national ETS in order to reduce carbon price uncertainty within the ETS.

In order to provide clear forward price signals to investors, lawmakers should explicitly legislate a pre-set price path through to 2030 or 2035 that eventually converges with expected EU ETS2 prices. Determining a suitable price path, however, is a non-trivial endeavour. On the one hand, the carbon price should converge to expected ETS2 prices by around the time when Ukraine would join the EU, in order to avoid a sudden carbon price shock to industries. On the other hand, short-term carbon prices should be moderate to reduce adverse effects for competitiveness. Finally, the path itself should not be too steep to provide some adjustment time for businesses to invest in decarbonisation measures. Thus emerges a trade-off between the initial carbon price, the timing of convergence with EU ETS2 price levels, as well as the steepness and shape of the price path in between.

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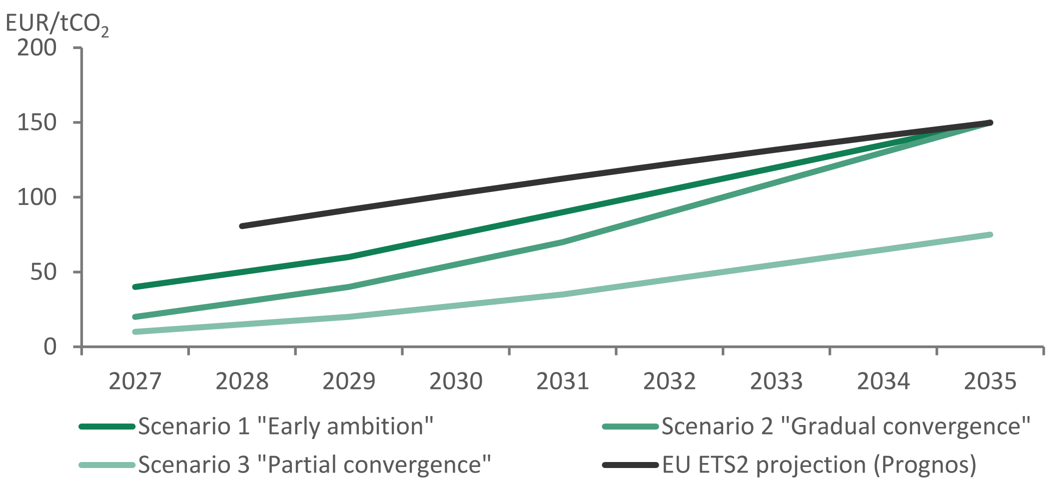
[21] Once Ukraine joins the European Union and fully participates in EU ETS2, the upstream carbon tax should be phased out in favour of the common European ETS2.

The question of timing for price convergence with the EU ETS2 involves an additional challenge – effectively, aiming for convergence with ETS2 prices means aiming for a moving (and uncertain) target. Projected ETS2 prices from Prognos[22] underline this fact: While a carbon price of 102 EUR/tCO_2 in the ETS2 is projected for 2030, the price for 2035 is expected to climb to 150 EUR/tCO_2. Delaying the point of convergence can thus only slightly reduce the required steepness of Ukraine's price path, as EU ETS2 prices are expected to be higher in the future. For any scenario with full price convergence, Ukraine's carbon tax requires a steeper price schedule than the expected ETS2 price path. A higher initial price level can dampen the required steepness but of course comes with a higher initial price burden (and decarbonisation incentive).

To illustrate these trade-offs, we consider **three carbon price scenarios**:

1. **Early ambition:** This scenario assumes an initial carbon price of 40 EUR/tCO_2 in 2027, considerably lower than EU ETS prices but economically significant for Ukraine, providing early incentives for decarbonisation. The price is assumed to rise to 75 EUR/tCO_2 in 2030 and converge to the expected EU ETS2 price of 150 EUR/tCO_2 in 2035.
2. **Gradual convergence:** This scenario begins with a moderate price of 20 EUR/tCO_2 in 2027, rising to 55 EUR/tCO_2 in 2030 and converging to the expected EU ETS2 price of 150 EUR/tCO_2 in 2035. While prices start from lower levels initially, the ramp up in the 2030s is steeper to achieve convergence by 2035.
3. **Partial convergence:** This scenario begins at 10 EUR/tCO_2 in 2027, increases to 27.5 EUR/tCO_2 in 2030 and only rises to 75 EUR/tCO_2 in 2035. Thus, it does not achieve convergence with ETS2 price levels, which either implies a sudden increase to EU ETS2 prices or no EU accession by 2035.

Figure 1: Scenarios for Ukraine's carbon price path vs. projected EU ETS2 prices



Source: Prognos (2025) and authors' own calculations

[22] Prognos (2025): *Rahmendaten für die Treibhausgas-Projektionen 2025 - Datentabelle*. Umweltbundesamt. (Link)

In order to understand how these carbon prices translate to tax rates under an upstream carbon tax, we can consider the tax rate per volumetric unit of fossil fuel, i.e. per litre of gasoline, diesel or LPG and per cubic metre of natural gas (see Tables 1 to 3). Please note that these rates should ideally come on top of the existing minimum fuel excise tax rates which address other externalities (road damage, congestion, accidents, local air pollution) while the carbon tax aims to address the external costs of greenhouse gas emissions.

Table 1: Scenario 1 "Early ambition" – carbon price and tax rate per litre or m^3

	2027	2028	2029	2030	2031	2032	2033	2034	2035
CO_2 price (EUR/tCO_2)	40	50	60	75	90	105	120	135	150
Gasoline tax rate (EUR-ct/l)	9,4	11,7	14,0	17,6	21,1	24,6	28,1	31,6	35,1
Diesel tax rate (EUR-ct/l)	10,7	13,4	16,1	20,1	24,2	28,2	32,2	36,2	40,3
LPG tax rate (EUR-ct/l)	6,3	7,8	9,4	11,8	14,1	16,5	18,8	21,2	23,5
Natural gas tax rate (EUR-ct/m^3)	7,6	9,5	11,4	14,3	17,2	20,0	22,9	25,7	28,6

Sources: Authors' own calculations

Table 2: Scenario 2 "Gradual convergence" – carbon price and tax rate per litre or m^3

	2027	2028	2029	2030	2031	2032	2033	2034	2035
CO_2 price (EUR/tCO_2)	20	30	40	55	70	90	110	130	150
Gasoline tax rate (EUR-ct/l)	4,7	7,0	9,4	12,9	16,4	21,1	25,8	30,4	35,1
Diesel tax rate (EUR-ct/l)	5,4	8,1	10,7	14,8	18,8	24,2	29,5	34,9	40,3
LPG tax rate (EUR-ct/l)	3,1	4,7	6,3	8,6	11,0	14,1	17,2	20,4	23,5
Natural gas tax rate (EUR-ct/m^3)	3,8	5,7	7,6	10,5	13,3	17,2	21,0	24,8	28,6

Sources: Authors' own calculations

Table 3: Scenario 3 "Partial convergence" – carbon price and tax rate per litre or m^3

	2027	2028	2029	2030	2031	2032	2033	2034	2035
CO_2 price (EUR/tCO_2)	10	15	20	28	35	45	55	65	75
Gasoline tax rate (EUR-ct/l)	2,3	3,5	4,7	6,4	8,2	10,5	12,9	15,2	17,6
Diesel tax rate (EUR-ct/l)	2,7	4,0	5,4	7,4	9,4	12,1	14,8	17,4	20,1
LPG tax rate (EUR-ct/l)	1,6	2,4	3,1	4,3	5,5	7,1	8,6	10,2	11,8
Natural gas tax rate (EUR-ct/m^3)	1,9	2,9	3,8	5,2	6,7	8,6	10,5	12,4	14,3

Sources: Authors' own calculations

4. Macroeconomic and distributional impact assessment

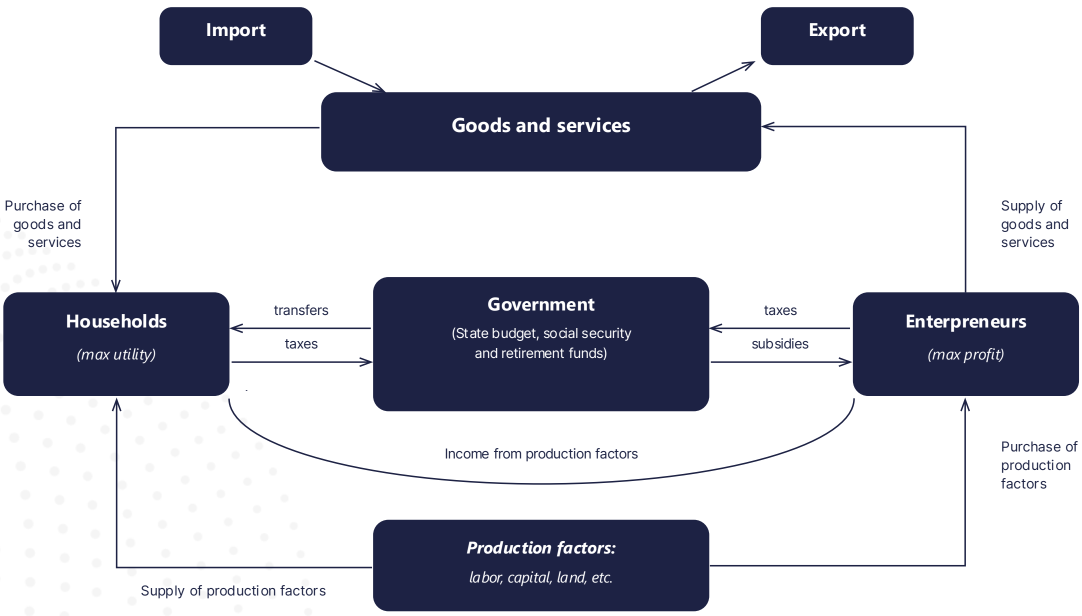
4.1 Methodology

Macroeconomic impact assessment

To assess the macroeconomic and distributional impacts of a carbon tax reform, we use the **ENVISAGE model**, a global **Computable General Equilibrium (CGE)** model. The model simulates the interactions between households, firms, government, and international trade across countries and sectors over time. It is calibrated using the **GTAP Circular Economy database** and runs over the period 2017–2035 with variable time steps.

The core economic logic of the model is illustrated in Figure 2, which shows the **circular flow of income and production** in the economy. Households supply production factors (e.g. labor, capital, land) and receive income in return. They use this income to consume goods and services, pay taxes, and receive transfers from the government. Entrepreneurs (firms) purchase production inputs and generate output, which is either consumed domestically or exported. The government collects taxes and redistributes income via transfers and subsidies. Goods and services can be imported or exported, and all prices and quantities are determined endogenously to ensure equilibrium in factor and product markets.

Figure 2: Circular flow structure in the ENVISAGE CGE model



Sources: Authors' own display

The model incorporates a wide range of **baseline assumptions** for Ukraine and the rest of the world:

- **Demographic assumptions**: Ukrainian population projections consider war-related displacement and assume reintegration of temporarily occupied territories by 2026. Global population assumptions are based on the SSP2 "middle-of-the-road" scenario.
- **GDP and productivity**: Ukraine's macroeconomic trajectory follows its official Low Emission Development Strategy (LEDS) draft, with GDP growing 5–6% annually in the long term. Labor productivity grows in line with GDP; agricultural productivity increases by 1% annually.
- **Energy system trends**: The share of electricity in final energy use rises significantly, especially in households and transport. Renewable energy grows steadily, driven by cost reductions and policy targets.
- **Carbon pricing**: The baseline includes a gradual increase in Ukraine's carbon price from ~1.1 EUR/tCO_2 in 2017 to ~4.4 EUR/tCO_2 in 2035. Other countries are assumed to meet their Nationally Determined Contributions (NDCs) and continue similar effort levels post-2030.
- **Emissions**: Under the baseline, Ukraine's emissions decline substantially after 2022 and remain below pre-war levels through 2035, due to structural changes in energy, industry, and household energy use.

Detailed methodological documentation, model parameters, and data sources are provided in the Annex II.1.

Distributional impact assessment

To assess the distributional effects of the carbon tax scenarios, we combine results from the CGE model with household-level microdata. Specifically, we take the model-based projections of changes in expenditure patterns for a representative household between 2017 and the four future scenarios (baseline plus three policy scenarios). These projected changes in spending across goods and services are then applied to microdata from Ukraine's Household Budget Survey (HBS). In doing so, we assume that all households share the same income and price elasticities as the representative household in the CGE model. This allows us to translate aggregate expenditure shifts into household-specific budget effects across the income distribution and for different household types. The approach captures how changes in both overall income levels and relative prices of goods and services affect household consumption structures under each scenario.[23] For more details, see Annex II.2.

4.2 Modelling results

Macroeconomic impacts

At the macro level, the implementation of ambitious mitigation policies leads to a moderate slowdown in the growth rates of the welfare and GDP (Figure 3). Welfare[24] declines by 2%-2.5% w.r.t baseline levels in 2035 (Figure 3a), which

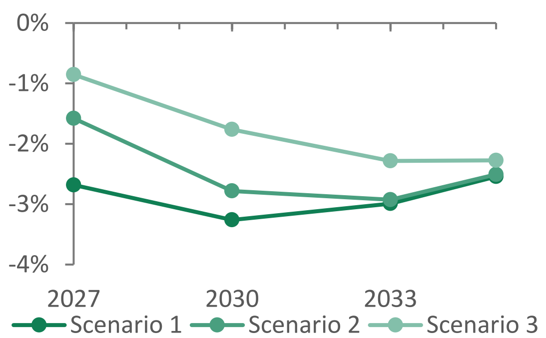
[23] Importantly, we assume that the share of the total energy bill covered by the housing and utilities subsidy (HUS) remains constant compared to the base year of 2016. Only the impact of the remainder of the bill, paid for by the households themselves, is considered in the impact assessment.

[24] Welfare in the model is measured using the notion of equivalent variation. The equivalent variation is the change in wealth, at current prices, that would have the same effect on consumer welfare as would the change in prices, with income unchanged. In other words, equivalent variation is defined to be the level of

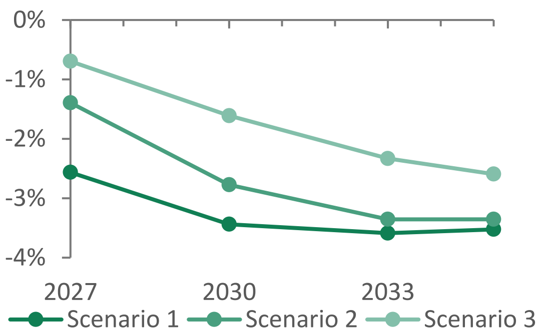
translates to a reduction in the annual growth rate of around 0.2-0.3 percentage points. While by the end of the analysed period, welfare impacts are rather close across all three scenarios (and not much lower under the less ambitious "Partial convergence" case), much more difference is observed during the first years of implementation, as the levels of carbon prices differ substantially across scenarios. In 2027, under the least-ambitious "Partial convergence" case and 10 EUR per tCO_2, welfare impacts are less than 1% (w.r.t. baseline levels), while in the case of "Early ambition" scenario with 40 EUR per tCO_2, the welfare costs are over 2.5% in 2027. In the case of higher-ambition scenarios, welfare impacts both in the "Early ambition" and "Gradual convergence" scenarios are higher in the middle of the analysed period (2030-2033), than at the end. In the case of GDP, the scope of the macroeconomic impacts is similar to welfare, with reductions reaching 2.5%-3.5% in 2035 w.r.t. baseline levels (Figure 3b). These changes translate to the reductions in annual growth rates in the range of 0.3-0.4 percentage points. Implementation of carbon pricing also leads to an increase in consumer prices, with aggregate consumer price index (CPI) ranging from a 1.4% increase under the "Partial convergence" scenarios in 2035 (compared to baseline levels) to around 2% increase under the "Early ambition" case.

Figure 3: Macroeconomic impacts of carbon pricing in Ukraine

a) Change in welfare[24], % w.r.t. baseline levels



b) Change in GDP, % w.r.t. baseline levels



Sources: Authors' own calculations and modelling

It should be noted that the estimated macro impacts essentially capture the costs of carbon pricing policies, without explicitly taking into account any co-benefits of such an action. The latter might include a reduction in climate damages (though these would primarily be realized under global climate action case), health improvements due to the reduction in pollution levels, reduction in water and soil pollution, as well as benefits to biodiversity, among others. In addition, the current implementation captures the impact of carbon pricing policies in Ukraine only under unchanged climate mitigation efforts in the rest of the world, essentially giving Ukraine's trading partners a comparative advantage in terms of costs of production and environmental stringency (except for the EU and UK, though climate policies in the latter regions are still part of the baseline scenario). In addition, the scenario implementation does not include any external co-financing

income needed to attain utility level *u* at base year prices. In the CGE models like ENVISAGE, welfare is a more comprehensive measure of the overall macro impacts of the specific policies compared to GDP, as the former captures the terms of trade effects.

of the domestic mitigation policies in Ukraine (e.g., from EU funds), thus likely representing an upper bound of the potential policy impacts.

Sectoral impacts

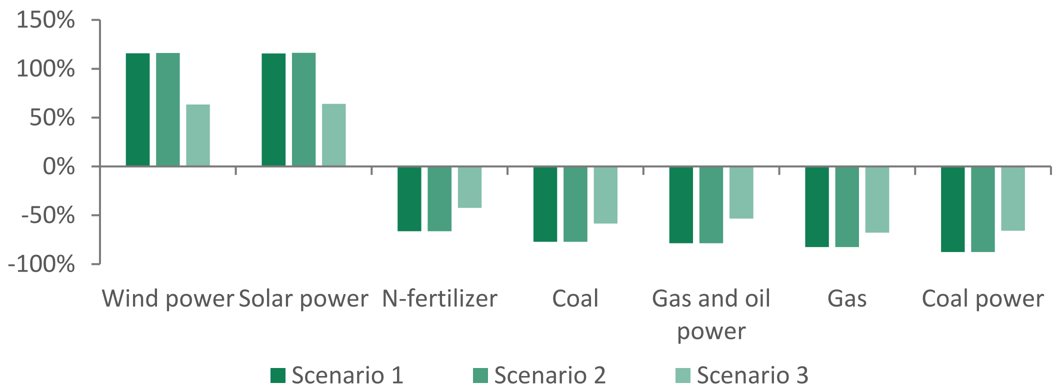
As carbon prices are imposed, this leads to higher production costs, particularly in the emission-intensive activities, and reallocation of resources toward other, less carbon-intensive sectors. While aggregate output declines in a range of 2.4% (Scenario 3) to 3.2% (Scenarios 1 and 2) in 2035 (Figure 3b), when compared to the baseline levels, impacts for specific sectors are much more substantial (Figure 4a and b). Carbon-free electricity generation activities are among the sectors that benefit the most following the implementation of carbon prices. Under more ambitious scenarios, selected renewable generation technologies, such as solar and wind power, more than double their output in 2035, when compared to the baseline levels, while nuclear, hydro and other renewable power generation see an increase of around 15%-20% (Figure 4a). On the other hand, fossil-based power generation (gas and coal power) and fossil fuels (coal and gas) are among sectors that see major declines in output – by around 80%-90% under the "Early ambition" and "Gradual convergence" scenarios, and by around 60%-70% under the "Partial convergence" case. Other energy-intensive sectors, such as fertilizers, iron and steel production, oil refining, aluminium production, cement, as well as transport services, see a decline in output of up to 20%-30% in 2035 (Figure 4b). As in the case of GDP, in most sectoral cases, these declines do not indicate the absolute reduction in output, but rather a slowdown in the growth rate.

Environmental impacts and fiscal revenues

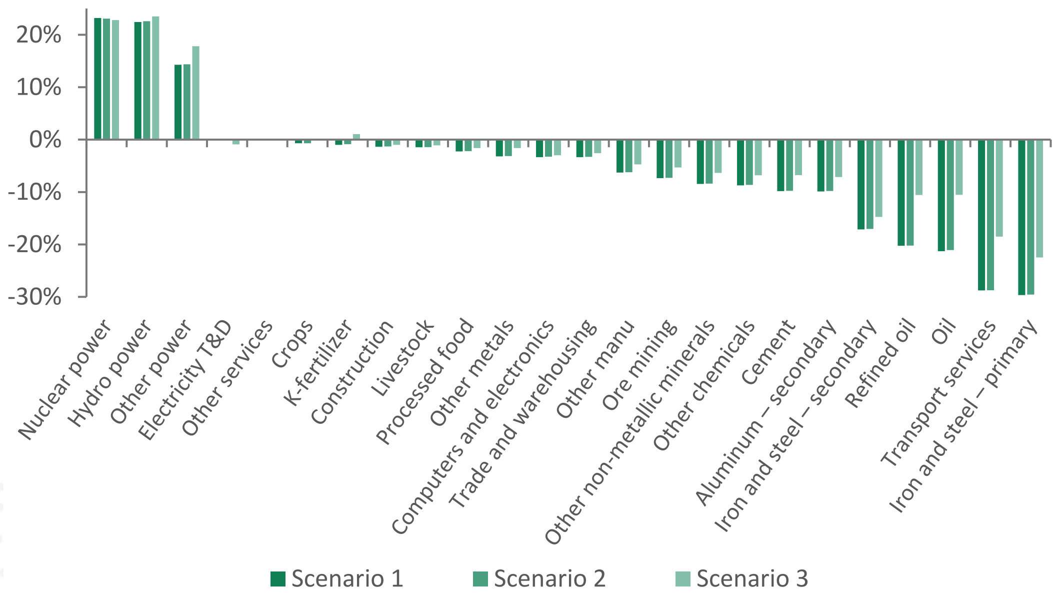
Considering the high level of mitigation ambition across the analysed scenarios, it is important to understand the environmental implications of these policies, as well as the related fiscal revenues that could potentially be used across a range of applications. Results suggest that CO_2 emissions decline by up to 50% in 2035 (w.r.t. baseline scenario levels) under "Early ambition" and "Gradual convergence" scenarios and by around 35% under the "Partial convergence" case (Figure 5a). As carbon prices increase over time, their marginal impact on relative emission reductions declines, as more affordable abatement options are utilised first. Looking at the reduction in emissions across sectors in 2035, across all scenario cases, most substantial reductions are coming from the electricity and heat generation activities, representing almost 60% of total CO_2 emission reductions in all scenario cases (Figure 5b). Industry represents around 20% of all emission reductions across scenarios, followed by transport and households (Figure 5b), with the strongest emission reduction within the industry coming from iron and steel and coal (Figure 5c). It should be noted that in the developed model, private transportation (residential vehicles, motorcycles, etc.) is classified under the household consumption category.

Figure 4: Impacts on sectoral output under carbon pricing scenarios in Ukraine

a) Change in output for most-impacted sectors in 2035, % w.r.t. baseline levels



b) Change in output for other sectors in 2035, % w.r.t. baseline levels

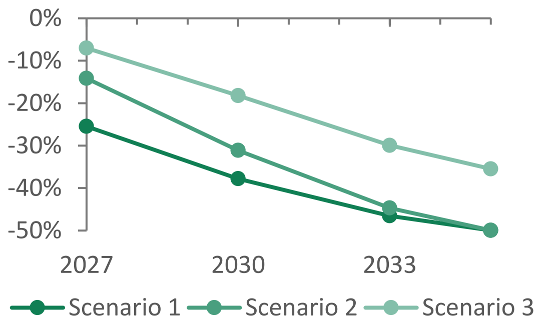


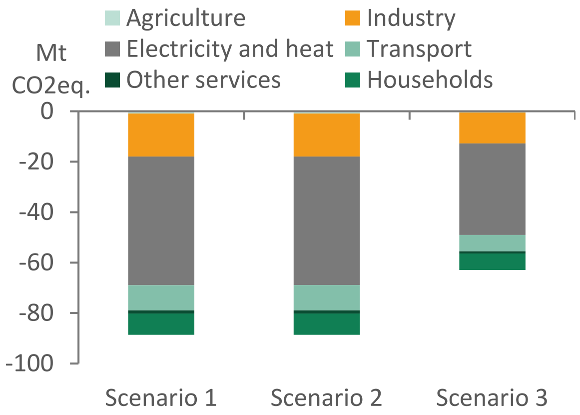
Sources: Authors' own calculations and modelling

Figure 5: Change in CO2 emissions under mitigation scenarios in Ukraine

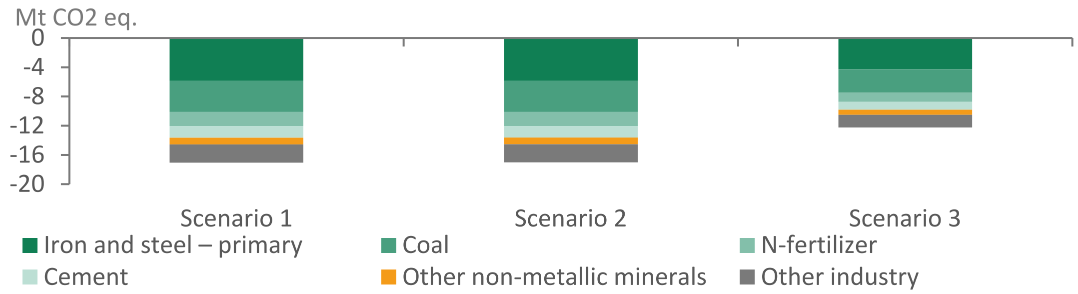
a) Change in CO2 emissions, % w.r.t. baseline levels

b) Change in CO2 emissions by sectors, Mt CO2 eq. w.r.t. baseline scenario levels in 2035





c) Change in CO2 emission by industry sub-sector, Mt CO2 eq. w.r.t. baseline scenario in 2035



Sources: Authors' own calculations and modelling

In the baseline scenario, with carbon prices not exceeding 4 EUR per tCO_2 in 2035, the generated carbon revenue is relatively low – reaching around 391 million EUR in 2035 (Table 4), which corresponds to less than 0.2% of Ukraine's GDP in the same year. Under the third scenario "Partial convergence", the generated carbon revenue starts at around 1.27 billion EUR in 2027 and exceeds 6.6 billion EUR in 2035 (corresponding to around 3.2% of GDP). Under the other two scenarios, carbon revenue reaches 9.7 billion EUR in 2035 (corresponding to 4.7% of GDP).

Table 4: Revenue from carbon pricing across scenarios (2023 EUR, m)

	2027	2030	2033	2035
Baseline	172.8	238.2	314.3	390.9
Scenario 1	3974.2	6242.3	8468.3	9730.0
Scenario 2	2322.0	5144.3	8082.5	9732.6
Scenario 3	1264.8	3111.7	5330.5	6619.9

Sources: Authors' own calculations and modelling

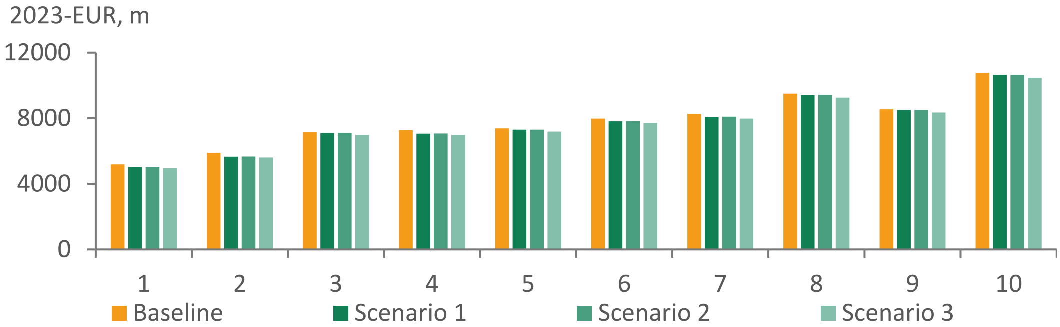
Distributional impact assessment

To analyse distributional effects, we compare the absolute and relative energy expenditure of households across income groups. In absolute terms, higher-income households spend more on energy (Figure 6a, baseline). However, in relative terms, lower-income households devote a larger share of their income to energy, particularly for residential uses such as electricity, heating, and natural gas (Figure 6b, baseline). Consequently, rising energy prices without social compensation can have regressive effects, disproportionately burdening poorer households.

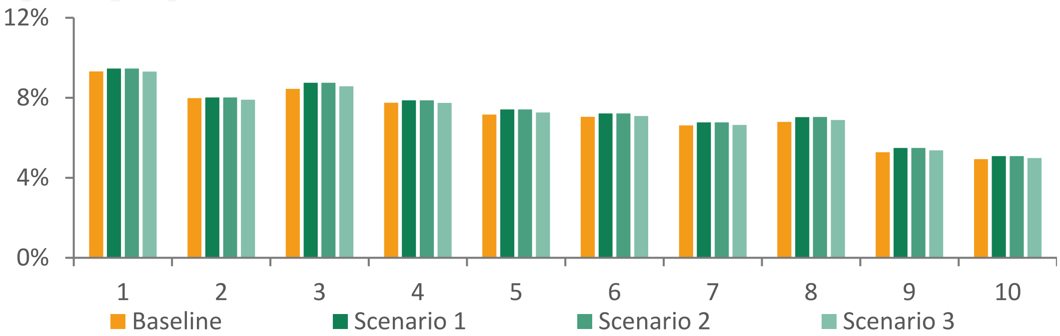
When comparing absolute residential energy expenditure between the baseline and the three carbon tax scenarios, it is striking that expenditure actually falls in all income deciles under higher carbon taxes (Figure 6a). This may appear counterintuitive, since higher prices for certain energy carriers in itself could lead to higher spending. Yet, at the same time, in relative terms, residential energy expenditure as share of income slightly increases (Figure 6b, Figure 7). For absolute expenditure to go down while prices go up, households must decrease their volume of energy consumption or shift it to cheaper energy carriers. The slight rise in relative expenditure suggests that, despite these adjustments, the lower spending on residential energy is not sufficient to fully offset the lower effective income relative to the baseline (see welfare losses compared to the baseline scenario).

Figure 6: Residential energy expenditure by income decile, 2035

a) Absolute residential energy expenditure

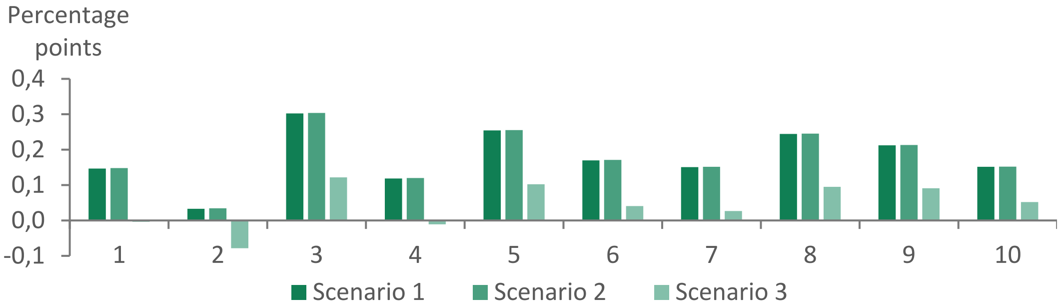


b) Relative residential energy expenditure, % of total household income



Sources: Authors' own calculations and modelling

Figure 7: Change in relative residential energy expenditure income with respect to baseline scenario by income decile, 2035

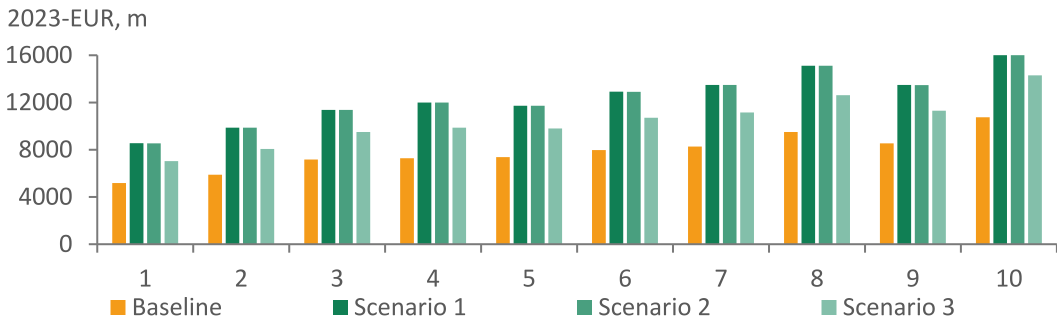


Sources: Authors' own calculations and modelling; Note: Percentage point difference between residential energy expenditure as share of income in baseline and respective scenario.

Figure 8 further clarifies why households adjust consumption. In a counterfactual scenario where households maintain baseline energy use while facing higher carbon-taxed prices, absolute residential energy expenditure would increase substantially (by up to 67% in decile 2, panel a). Relative expenditure would also rise sharply, often exceeding 10% across scenario-decile combinations – a commonly used threshold for energy poverty (panel b).[25] This illustrates the necessity to react to the higher prices by lowering overall (residential) energy consumption or switching to other energy sources.

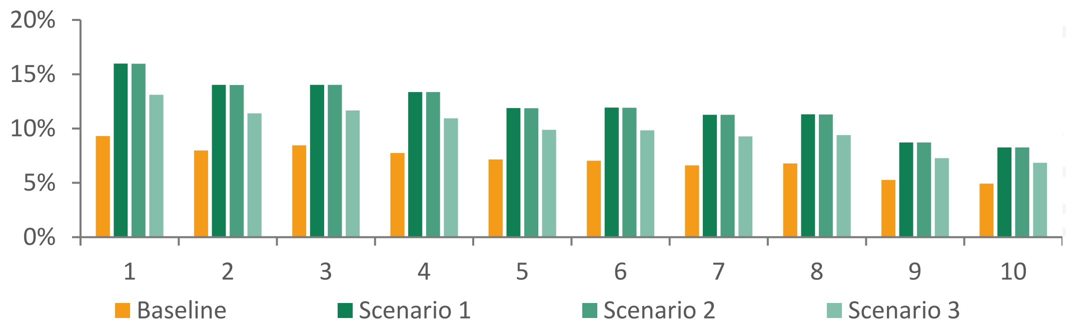
Figure 8: Counterfactual residential energy expenditure without volume substitution effect, 2035

a) Counterfactual absolute residential energy expenditure



[25] See for example Schuessler, R. (2014). *Energy poverty indicators: conceptual issues part I: the ten-percent-rule and double median/mean indicators*. ZEW Discussion Papers, 14. (Link)

b) Counterfactual relative residential energy expenditure, % of total household income



Sources: Authors' own calculations and modelling; Note: Absolute counterfactual (panel a) computed using baseline consumption volumes and prices of the respective scenario.

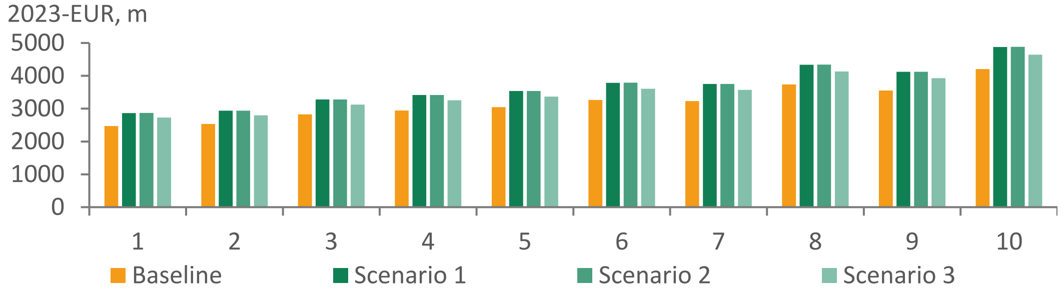
Looking more closely at the substitution between energy carriers (Figure 9) we observe different patterns across electricity (panel a), natural gas (panel b), solid fuels (panel c), and district heating (panel d). The most striking finding is the sharp decline in gas and solid fuel consumption under the carbon tax scenarios compared to the baseline. This reflects the clear comparative disadvantage of these carriers, owing to their high carbon intensity and thus higher relative costs – as already seen in the macro-modelling results. In contrast, both electricity and district heating see rising consumption across all income deciles. This indicates their relative attractiveness in the scenarios and points to the general trend of electrification. From a policy perspective, this is promising: if electricity generation increasingly comes from renewable sources with low generation costs, such a shift benefits both climate goals and consumers. It reduces carbon emissions while potentially stabilising or even lowering long-term energy prices.

However, there are important caveats. The model used here accounts for prices and household behaviour, including income and price elasticities, but it does not consider the technical feasibility of such a large-scale substitution. Key questions remain: can electricity supply realistically keep pace with increased demand? Is it technically feasible and financially affordable – especially for low-income households – to switch from gas or solid-fuel heating systems to electricity or district heating? If not, there is a risk that the model reflects economically optimal behaviour, while in practice some households could be left without adequate technical or monetary means to sufficiently heat their homes.

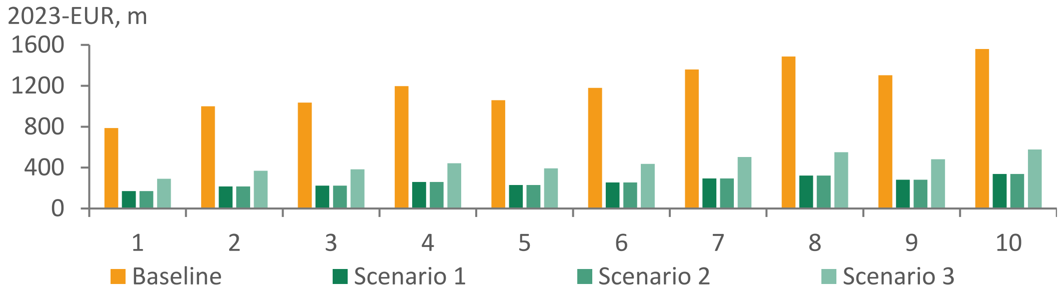
Finally, regarding non-residential energy consumption, motor fuels for individual transport show a particularly pronounced difference between lower- and higher-income deciles in absolute terms (Figure 9e). Here, too, higher carbon taxes reduce the attractiveness of this carrier, disproportionately incentivising higher-income groups to adjust their transport behaviour. This underlines both the potential for demand-side changes in mobility patterns and the importance of ensuring that such adjustments do not deepen social inequalities.

Figure 9: Expenditure on individual energy sources by income decile, 2035

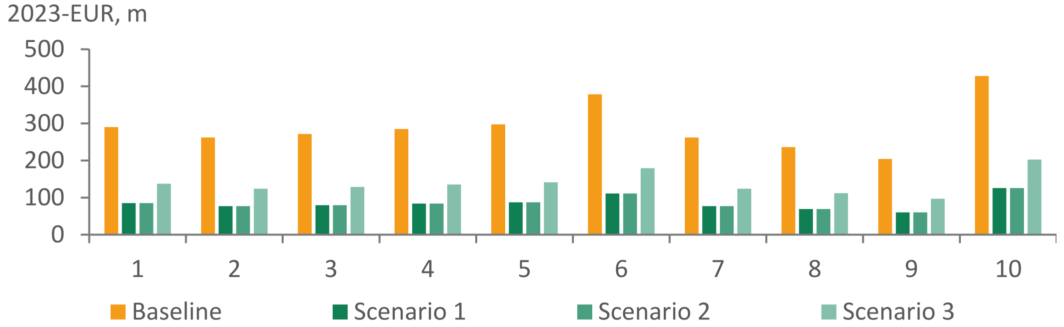
a) Absolute electricity expenditure



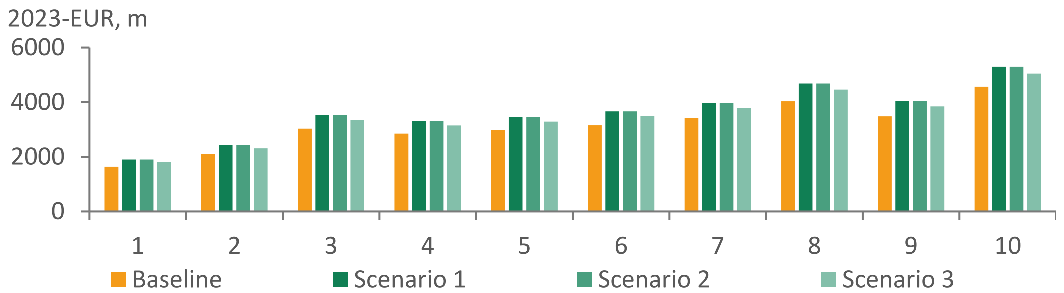
b) Absolute natural gas expenditure



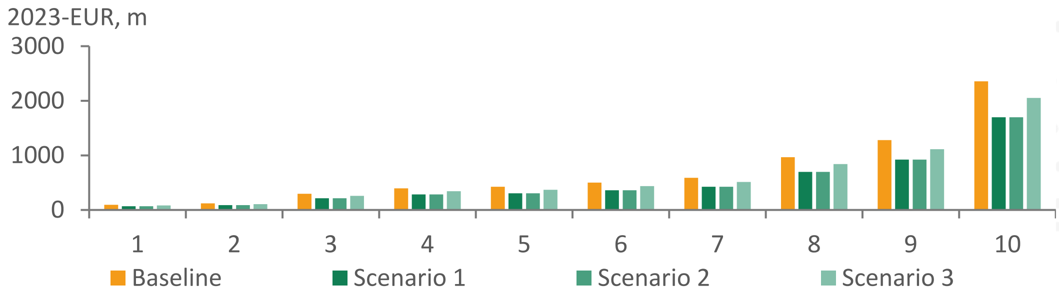
c) Absolute solid fuels expenditure



d) Absolute district heating expenditure



e) Non-residential energy: Absolute motor fuel expenditure for individual transportation

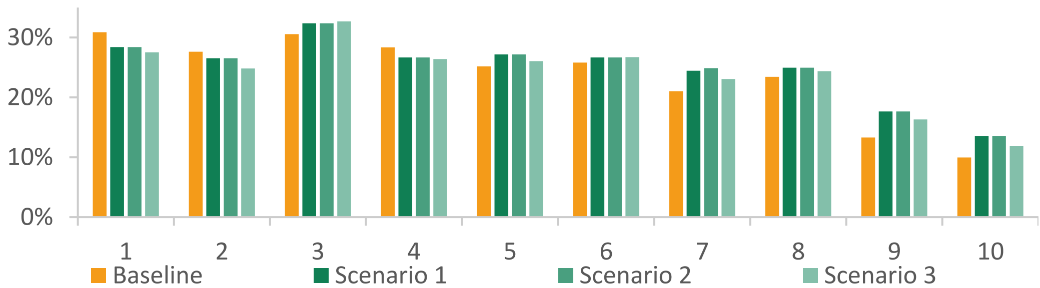


Sources: Authors' own calculations and modelling

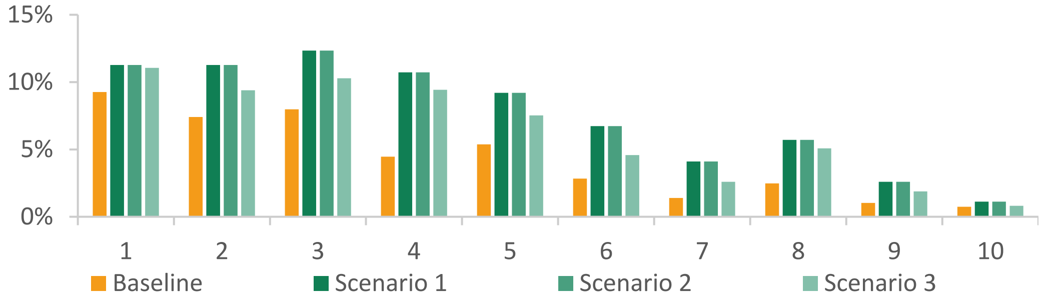
Turning to household energy burdens, we examine the share of households within each decile that spend a substantial proportion of their total income on residential energy consumption. While substitution effects may allow some low-income households to reduce their energy spending to below 10% of income (bearing in mind the technical caveats noted above), in most income deciles the share of households exceeding this threshold rises under the higher carbon tax scenarios (Figure 10a). Importantly, although the levels are much lower, the share of households spending even more than 20% of their income on residential energy also increases noticeably across all deciles (Figure 10b).

Figure 10: Share of households at risk of energy poverty, 2035

a) Share of households spending more than 10% of total income on residential energy



b) Share of households spending more than 20% of total income on residential energy



Sources: Authors' own calculations and modelling

5. Discussion of economic and distributional effects and using revenues to reduce adverse impacts

The modelling results highlight both the **opportunities and the challenges of an ambitious carbon tax reform** in Ukraine. The reform has clear potential to deliver **substantial emission reductions – up to 50% relative to baseline levels by 2035** under the more ambitious scenarios – while generating **significant fiscal revenues of up to 4.7% of GDP**. These gains come at the cost of a **modest slowdown in macroeconomic growth**, as well as distributional concerns for households, and structural adjustments for carbon-intensive sectors.

At the macroeconomic level, welfare and GDP growth are projected to decline slightly relative to baseline, with losses in the order of 0.2–0.4 percentage points in annual growth. While these costs are not negligible, they remain within the range observed in other countries that have implemented ambitious carbon pricing schemes. Moreover, the estimates represent an upper bound, since they do not account for potential co-benefits such as reduced air pollution, improved health outcomes, and avoided climate damages. From a dynamic perspective, the carbon tax can also act as a structural driver of modernisation by accelerating investment into renewable energy, electrification, and energy efficiency, thereby strengthening long-term resilience of the Ukrainian economy.

Sectoral impacts are unevenly distributed. Carbon-free electricity generation, particularly solar and wind, emerges as a clear beneficiary, with output more than doubling by 2035 under ambitious scenarios. By contrast, fossil-based generation and energy-intensive industries such as steel, cement, and fertilisers face declining output growth. These distributional effects across sectors underline the importance of complementary industrial and just transition policies to facilitate reallocation of labour and capital, and to avoid localised economic disruptions.

For households, the distributional analysis confirms the regressive nature of higher energy prices. While absolute expenditures on residential energy tend to decline as households substitute away from carbon-intensive fuels, relative burdens increase, especially for lower-income deciles. The share of households spending more than 10% or even 20% of income on energy rises under higher carbon tax scenarios, signalling risks of energy poverty. These effects are further complicated by the technical feasibility of substitution: while the model assumes significant electrification of heating and transport, in practice households may lack the upfront capital or infrastructure to switch away from gas or solid fuels. Without targeted support, vulnerable groups could therefore face disproportionate hardships.

These challenges underline the crucial role of revenue recycling. With potential revenues amounting to several percent of GDP, Ukraine would have significant fiscal space to offset regressive impacts, support vulnerable households, and invest in the green transition. International experience, including lessons from the EU ETS, shows that earmarking a significant share of auctioning revenues for climate and social objectives has been central to sustaining public and political support. For Ukraine, options include direct transfers or rebates to households, targeted subsidies for energy efficiency improvements, and expansion of social assistance programmes such as the Housing and Utilities Subsidy (HUS) scheme.

Beyond compensation, revenues could be used strategically to attract EU co-financing for decarbonisation investments, such as via a reformed Decarbonisation and Energy-Efficient Transformation Fund (DETF) with shared Ukraine-EU governance, modelled after Ukraine's Energy Efficiency Fund (EEF). Matching Ukrainian ETS and carbon tax revenues with EU funds in a reformed DETF would also increase incentives for Ukraine to set a more ambitious carbon tax price path. Project selection criteria could be based on the EU's Modernisation Fund. Such a reformed fund could institutionalise the investment support currently provided under Pillar II of the Ukraine Facility "mobilising large-scale, long-term capital to modernise [Ukraine's] industry in line with the EU's Clean Industrial Deal."[26]

International precedent also suggests that coupling social transfers with visible investment in clean infrastructure—such as district heating modernisation, electrification of transport, and industrial decarbonisation—enhances both environmental effectiveness and public trust. Thus, transparent, predictable, and well-communicated revenue use is likely to be decisive for the long-term success of Ukraine's carbon tax reform.

Finally, Ukraine's EU accession perspective and exposure to the EU Carbon Border Adjustment Mechanism (CBAM) add a strategic dimension. A reformed carbon tax that converges toward EU ETS2 price levels will reduce CBAM adjustment costs and retain revenues domestically. In this sense, the reform is not only a climate policy instrument but also an industrial and geopolitical one, aligning Ukraine more closely with EU regulatory frameworks and ensuring competitiveness of its exports.

In summary, the **modelling results suggest that carbon tax reform** in Ukraine can be **both environmentally effective and fiscally productive**, but only if accompanied by **robust distributional safeguards and credible reinvestment of revenues**. The policy challenge lies in carefully sequencing the price path, designing transparent compensation measures, and coupling fiscal reform with structural investments that accelerate Ukraine's low-carbon transition.

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[26] Sicheneder, A., Zachmann, G., & Savytskyi, O. (2026). *Scaling Up for Europe: Strategic Options for a high-impact Fund driving Ukraine's Decarbonisation and Clean Industrialisation*. Green Deal Ukraïna Policy Report. (forthcoming)

6. Conclusion

This study has shown that Ukraine's carbon tax reform is both necessary and feasible but also complex in its political economy. Ukraine faces a dual challenge: the urgent need to align with EU climate policy in the context of accession negotiations, and the simultaneous imperative of rebuilding an energy and industrial system devastated by war. While carbon taxation is not a new instrument for Ukraine, the current regime is too weak, fragmented, and ineffective to deliver meaningful decarbonisation. Against this backdrop, the modelling results confirm that an ambitious reform towards an upstream, fuel-based carbon tax in line with Ukraine's National Revenue Strategy, and with economically significant tax rates can unlock substantial emissions reductions and fiscal revenues, while creating the policy certainty needed to guide long-term investments.

The reviewed international experience underscores why carbon taxation, when embedded in a broader climate architecture, can be a cornerstone policy. The analysis of EU member states shows that the credibility of carbon pricing depends not only on tax design but also on its integration with energy market reforms, emission trading systems, and social compensation mechanisms. Countries that have successfully implemented ambitious carbon prices, such as Sweden or Denmark, have combined stable price trajectories with strong recycling of revenues into both social protection and green investment. These lessons are highly relevant for Ukraine: a carbon tax aligned with the forthcoming EU ETS2 can position the country as a credible accession candidate while also helping to avoid excessive CBAM-related adjustment costs.

This study outlines a concrete proposal for reform, namely an ambitious upstream carbon tax with expanded scope and a price path converging to EU ETS2 levels. The modelling results reinforce the viability of this proposal: revenues equivalent to several percent of GDP can be generated, regressive impacts could be mitigated through targeted compensation, and sectoral shifts can accelerate the transition towards clean power and electrification. Yet, the results also highlight that design choices will determine whether the reform strengthens or undermines social cohesion. A phased price increase, robust monitoring and verification, and clear rules for interaction with the forthcoming ETS will be essential to ensure predictability and fairness.

The analysis further demonstrates that revenue recycling is the linchpin of success. Without transparent use of revenues, the reform risks eroding public support and exacerbating inequality. With credible recycling, however, the reform can protect households, bolster industrial competitiveness, and leverage EU co-financing for Ukraine's reconstruction. In this sense, the carbon tax is not simply a fiscal or environmental instrument: it is a bridge between Ukraine's immediate social needs, its medium-term reconstruction goals, and its long-term integration into the EU's climate and energy framework.

An ambitious carbon tax reform offers Ukraine a pathway to reconcile climate ambition with economic recovery and European integration. The modelling has confirmed its potential effectiveness, but the political and social dimensions are equally decisive. If paired with targeted social compensation, clear institutional design, and strategic reinvestment into green infrastructure, the reform can become a cornerstone of Ukraine's low-carbon future. As such, the carbon tax should be understood not as an isolated policy, but as an integral element of a wider reform package that supports reconstruction, advances EU accession, and ensures Ukraine's resilience in the face of both domestic and global challenges.

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Annex I: Overview of carbon tax design in the EU

Table A1: Overview of carbon tax design in the EU

	Sweden	Ireland	France	Luxembourg	Latvia	Slovenia	Estonia *	Germany	Austria	Portugal	Netherlands	Denmark **
Legal instrument	Other - stand-alone act - Carbon tax introduced by Carbon Tax Act (1990:582) effective 1991; incorporated into the Excise Duties on Energy Act (1994:1776)	Excise Law - Finance (No. 2) Act 2010 introduced carbon charges on mineral oil, natural gas and solid fuels; Finance Act 2020 legislates annual increases	Excise Law - Contribution climat énergie introduced by Finance Act 2014; integrated into domestic consumption taxes (TICPE, TICGN, TICC)	Excise Law - Law of 23 Dec 2020 (Budget Law 2021) introduced a CO_2 tax on fuels	Other - stand-alone act - Natural Resources Tax Law (with amendments) governs the CO_2 emissions tax	Other - Cabinet decree	Other - stand-alone act - Other Environmental Charges Act	Other - stand-alone act - Fuel Emissions Trading Act adopted 2019 establishes a national CO_2 emissions trading system from 2021	Other - stand-alone act - National Emissions Certificate Trading Act 2022 (Nationales Emissionszertifikat ehandelsgesetz 2022 - NEHG 2022)	Excise Law - Law 82-D/2014 (Green Tax Reform) amended the Excise Code to introduce a carbon tax (article 92-A); Portaria 384/2017 sets the rate for 2018	Other - stand-alone act - Industrial CO_2 Tax Act (Wet belasting op milieugrondslag) effective 1 Jan 2021 creates national CO_2 levy for industry	Act on tax on CO_2e emissions from quota-regulated sectors (Lov om afgift af CO_2e-emissioner fra kvoteomfattede sektorer) as proposed in Bill L 182
Tax base - Basis	Fuel Approach - Tax on CO_2 emissions from fossil fuel combustion, levied per tonne of CO_2	Fuel Approach - Excise charges per tonne of CO_2 on fossil fuels	Fuel Approach - Charge per tonne of CO_2 based on carbon content of fuels	Fuel Approach - Charge per tonne of CO_2 emitted by fossil fuels	Direct emissions approach - Tax on tonnes of CO_2 emitted from stationary installations	Fuel Approach	Direct emissions approach - Measured emissions	Direct emissions approach - Certificates per tonne of CO_2 (emissions trading)	Direct emissions approach - Emission certificates per tonne of CO_2 equivalent	Fuel Approach - Additional levy per tonne of CO_2 on certain energy products	Direct emissions approach - Levy per tonne of CO_2 emitted above free allowances	Tax on CO_2e emissions from industrial installations
Tax base - Gases	CO_2 only	CO_2 only	CO_2 only	CO_2 only	CO_2 only	CO_2 only	CO_2 only	CO_2 only	CO_2 equivalents	CO_2 only	CO_2 only	CO_2 equivalents
Fuel scope	All fossil fuels - All major fossil fuels (petrol, diesel, heating oil, natural gas, coal); biofuels exempt	All fossil fuels - Petrol, diesel, kerosene, marked gas oil, fuel oil, LPG, natural gas and solid fuels (coal, peat)	Motor & heating fuels - Petrol, diesel, heating oil, natural gas and coal, via energy excises	Motor & heating fuels - Fossil fuels for transport and heating - petrol, diesel, fuel oil and natural gas	Process emissions only - Emissions from combustion of fuels in small stationary installations (non-ETS)	Motor & heating fuels	All combustion fuels + process CO_2 - All fossil-fuel combustion streams (and any process CO_2 emitted)	Motor & heating fuels - Heating and transport fuels: petrol, diesel, heating oil, natural gas, LPG	All fossil fuels - Fossil energy sources: petrol, diesel, heating oil, natural gas, LPG, coal and kerosene	All fossil fuels - Petrol, diesel, marked gas oil, heating oil, LPG, natural gas, fuel oil, coal and coke	Process emissions only - Process emissions and fuel combustion in large industrial installations; not a fuel tax	Emissions from fossil fuel combustion in ETS industries; not fuel-specific
Sector coverage	Economy-wide - Transport, heating and other non-ETS sectors; manufacturing and heat production in EU ETS pay reduced or zero carbon tax	Specific sectors (transport, buildings & other non-ETS) - Transport, residential heating and other non-ETS sectors; operators in EU ETS and	Specific sectors (transport, heating, small industry) - Transport, residential heating and small industrial sectors outside EU ETS	Specific sectors (transport & buildings) - Households and businesses outside EU ETS	Specific sectors (small stationary installations) - Small stationary energy and industrial installations outside EU ETS	Specific sectors (transport & heating)	Specific sectors (stationary energy & small industry) - Stationary energy (heat & small industry outside EU ETS)	Specific sectors (buildings, transport & small industry) - Buildings and transport sectors and small industry outside EU ETS	Specific sectors (buildings, transport, agriculture, waste & small industry) - Buildings, transport, agriculture, waste and small	Economy-wide - Transport, heating and industrial fuel use; applies to all sectors via fuel excises	Manufacturing & construction (industry) - Large industrial plants under EU ETS; waste incinerators (from 2028) and nitrous oxide emitters	Companies covered by the EU ETS; mineralogical processes pay reduced rate

	Sweden	Ireland	France	Luxembourg	Latvia	Slovenia	Estonia *	Germany	Austria	Portugal	Netherlands	Denmark **
		certain activities receive reliefs							industrial plants outside EU ETS.			
Point of obligation	Upstream (fuel suppliers) - Registered fuel suppliers and importers when fuel is produced/imported and released from tax warehouse	Upstream (fuel suppliers) - Licensed fuel suppliers and first suppliers of natural gas and solid fuel	Upstream (fuel suppliers) - Fuel suppliers/importers when products are released for consumption	Upstream (fuel suppliers) - Fuel distributors when placing fuels on the market	Downstream (emitters) - Operators of stationary installations who calculate tax based on fuel consumed and emission factors	Upstream (fuel suppliers)	Downstream (emitters) - Downstream (permit-holding emitter)	Upstream (fuel suppliers) - Upstream fuel distributors and suppliers that place fuels on the market	Upstream (fuel suppliers) - Trading participants (fuel suppliers) who place fuels into free circulation must purchase certificates	Upstream (fuel suppliers) - Energy product suppliers when releasing fuels for consumption	Downstream (emitters) - Operators of ETS installations pay levy on emissions beyond dispensation rights	ETS installations/emitters pay tax based on verified emissions
Overlap with ETS	ETS sectors exempt - ETS installations (manufacturing and CHP) are exempt or pay only energy tax	ETS sectors exempt - Fuels used in EU ETS installations exempt	ETS sectors exempt - ETS installations exempt	ETS sectors exempt - ETS installations exempt	ETS sectors exempt - Operators in EU ETS exempt from the CO_2 tax	ETS sectors exempt	ETS sectors exempt	ETS sectors exempt - EU ETS sectors exempt; national ETS covers fuels not in EU ETS	ETS sectors exempt - EU ETS installations and negligible emitters (<1 t CO_2e) are exempt	ETS sectors exempt - ETS installations may be exempt or receive adjustments	Dual pricing (ETS + tax) - Levy is additional to EU ETS; net tax equals tariff minus EU ETS price	Additional to EU ETS; non-ETS sectors subject to separate CO_2 tax
Initial nominal rate	250 SEK/t CO_2 at introduction in 1991	EUR 15/t CO_2 when introduced in 2009/2010	EUR 7/t CO_2 in 2014; raised to 14.5 EUR (2015), 22 EUR (2016), 30.5 EUR (2017) and 44.6 EUR (2018); increases suspended thereafter	EUR 20/t CO_2 from 1 Jan 2021	2.85 EUR /t CO_2 in 2014; 3.50 EUR /t (2015-16); 4.50 EUR /t from 2017		EUR 25/t CO_2 (effective 1 Jul 2024)	EUR 25/t CO_2 in 2021	EUR 30/t CO_2e from Oct 2022; EUR 32.5 (2023); EUR 45 (2024); EUR 55 (2025)	Tax set annually based on EU ETS allowance price; Portaria 384/2017 fixed 6.85 EUR /t CO_2 for 2018	Tariff EUR 30.48/t in 2021; EUR 41.75 (2022); EUR 55.94 (2023); EUR 74.17 (2024); EUR 87.90 (2025); increases continue to 152.10 EUR /t in 2030	375 DKK/t CO_2 for ETS companies starting 2025; 125 DKK/t for mineralogical processes; (separate law proposes 750 DKK/t for non-ETS sectors)
Escalation rule	CPI indexation - Rates indexed annually to the consumer price index since 1994	Fixed annual step - Annual increases of about EUR 7.5/t to reach EUR 100/t by 2030; rate EUR 56/t CO_2 in 2024	Fixed annual step (suspended) - Originally scheduled to rise to 100 EUR /t by 2030, but rates frozen at 44.6 EUR /t since 2018	Fixed annual step - Increases by EUR 5/t each year; planned to reach EUR 45/t in 2026	None (flat) - Rates set by law; increases occur via amendments; no automatic indexation	None (flat)	None (flat) Act sets one rate, no future schedule	Fixed annual step - Fixed price increases to EUR 55/t by 2025; price corridor of EUR 55-65 in 2026	Fixed annual step - After 2025 the price is market-based with a price corridor; 2022-25 prices fixed	Scheduled review & reset - Rate determined each year by ministerial order, reflecting average EU ETS price	Fixed annual step - Annual increases set by law; from 2025 the tariff rises by EUR 12.84 each year; schedule published through 2030	Phased in from 2025 to 2030 with stepwise increases to full rate by 2030
Collecting agency	Hybrid - Swedish Tax Agency and Swedish Customs	Tax Service - Revenue Commissioners (Irish tax authority)	Customs - General Directorate of Customs and Indirect Duties (DGDDI)	Tax Service - Administration de l'Enregistrement, des Domaines et de la TVA (AED)	Tax Service - State Environmental Service	Tax Service	Hybrid Emitter files to the Environmental Board; Tax &	Energy Regulator - German Emissions Trading Authority (DEHSt) at the Federal	Customs - Office for National Emissions Certificates Trading within the	Tax Service - Autoridade Tributária e Aduaneira (Tax	Hybrid - Netherlands Emissions Authority (NEa) administers the	Danish Tax Agency (Skattestyrelsen)

	Sweden	Ireland	France	Luxembourg	Latvia	Slovenia	Estonia *	Germany	Austria	Portugal	Netherlands	Denmark **
					(declarations) and tax authority		Customs Board handles payment	Environment Agency	Customs Authority (Federal Ministry of Finance)	and Customs Authority)	levy; Tax and Customs Administration collects payments	
Use of revenue	Tax-shift (cuts) - General government revenue; used to offset other taxes	Mixed - Receipts above EUR 20/t ringfenced for climate action and social protection; remainder general revenue	Mixed - General budget; supports energy transition and compensations	Mixed - Revenue funds climate measures, social compensation (tax credit and cost-of-living allowance) and energy transition investments	Mixed - 60% of revenue to state basic budget; 40% to special environmental budget	General budget	General budget	Mixed - Revenue reinvested in climate protection measures and financial relief for citizens (reducing renewable energy levy, tax allowances and mobility premium)	Mixed - Revenue used to finance the climate bonus for households and support decarbonisation; general budget	Mixed - Revenue contributes to Environmental Fund and general budget; supports green tax reform	General budget - Revenue goes to general budget and funds climate transition; not explicitly earmarked	Revenues are recycled to businesses via green transition support and climate funds
% earmarked	0 (not earmarked)	Partial (portion above EUR 20/t)	Not specified	Partly earmarked for climate and social schemes	40 % for environmental protection			Majority earmarked for climate and relief measures	Partly earmarked for climate bonus	Not specified	Not specified	Portion earmarked for supporting the green transition of companies
Special provisions	EITE relief - Reduced rates and exemptions for energy-intensive industry, agriculture and international transport; tax suspension regime for tax warehouses	EITE relief - Reliefs for electricity generation, horticulture, fishing, disabled drivers and certain manufacturing	EITE relief - Refunds/exemptions for agriculture, taxis, fishing and energy-intensive industries	Household compensation - Social compensation for low-income households; possible reliefs for cross-border workers	Exempt fuels - Tax not paid for emissions from ETS installations or when using renewable energy and peat; tax multiplied by 10 for emissions above permit limit or without permit	EITE relief	None beyond ETS exemption (no size-threshold or offsets in CO_2 section)	Free allowances - Transitional free allocation for energy-intensive firms; small emitters exempt	EITE relief - Relief for agriculture/forestry and sectors at risk of carbon leakage; negligible emitters exempt	Exempt fuels - Refunds/exemptions for certain sectors such as agriculture, fisheries and electricity generation	Free allowances - Dispensation rights (free allowances) decline over time; waste incinerators included from 2028	Reduced rate for mineralogical processes; compensation schemes for energy-intensive sectors; agriculture and horticulture phase in later
MRV / penalties	Monthly tax returns; tax authority audits; penalties for late payment	Suppliers file returns; Revenue audits; penalties for non compliance	Standard excise tax compliance; penalties for non payment	Administered within excise system; penalties for non payment	Operators must report emissions; exceeding limits leads to ten fold tax; penalties for non compliance		Quarterly declaration to Environmental Board; overdue charges	Reporting and compliance based on EU ETS rules; fines for non compliance	Participants must surrender certificates annually; penalty of EUR 100 per tonne for non compliance	Collected with energy excises; penalties for non-payment	Based on EU ETS MRV; penalties apply for non compliance	Uses EU ETS MRV; penalties for non payment

Source: World Bank; various official sources mentioned in the chapter

* - 2000 to present; rate is shown as of 2024 hike;
** - 2025 industry levy

Annex II: Modelling methodology

II.1 Methodology CGE-Model

II.1.1 Global Trade Analysis Project (GTAP) Circular Economy Data Base

The core data input for the developed modelling framework is the Global Trade Analysis Project (GTAP) Data Base (Aguiar et al., 2023). GTAP is a global dataset that describes bilateral trade patterns, production, consumption and intermediate use of commodities and services in the countries/regions around the world. The 11th release of the GTAP Data Base, utilised in this study, has multiple reference years, with 2017 being the most recent one, covers 160 regions and disaggregates an economy in each region into 65 activities. The database reports emissions of CO_2 greenhouse gases (GHGs), non-CO_2 GHGs and air pollutants.

The version of the GTAP Data Base used in the current study is an extension of the standard GTAP Data Base, which is called the GTAP Circular Economy (GTAP-CE) database. The latter introduces additional disaggregation of selected GTAP sectors and incorporates material flow accounting for the selected commodities. The starting point for the disaggregation is the GTAP-Power 11 database with 76 sectors, 160 regions and a 2017 reference year (Chepeliev, 2023). Six sectors of the original GTAP-Power 11 database are further split into 29 sub-sectors, providing a more detailed representation of categories like metallic and non-metallic minerals mining, rubber and plastic products, iron and steel, non-ferrous metals, fertilizers and cement (Table A2). Corresponding sectoral splits are developed for all 160 regions reported in the GTAP-Power 11 database.

Table A2: An overview of the sectoral splits introduced to the GTAP-Power 11 database

No.	Original GTAP sector	New sector	Description
1	oxt	nmn	Non-metallic minerals mining
2		mio	Mining of iron ores
3		mao	Mining of aluminum ores
4		mcu	Mining of copper ores
5		moo	Mining of other ores
6	rpp	rbr	Rubber products
7		plp	Plastic products – primary
8		pls	Plastic products – secondary
9		plr	Recycling - plastics
10	nmm	cem	Cement
11		nmx	Other mineral products

No.	Original GTAP sector	New sector	Description
12	i_s	isp	Iron and steel – primary
13		iss	Iron and steel – secondary
14		ris	Recycling - iron and steel
15		isc	Iron and steel casting
16	nfm	app	Aluminum – primary
17		aps	Aluminum – secondary
18		ral	Recycling - aluminum
19		cpp	Copper – primary
20		cps	Copper – secondary
21		rcp	Recycling - copper
22		mpp	Other metals – primary
23		mps	Other metals – secondary
24		rom	Recycling - other metals
25		nfc	Non-ferrous metals casting
26	chm	nfr	Nitrogen fertilizer
27		pfr	Phosphorus fertilizer
28		kfr	Potassium fertilizer
29		xch	Other chemicals

II.1.2 Model dimensions

The GTAP V11 Circular Economy database has been aggregated into 19 regions and 31 sectors—the detailed aggregation mapping is available upon request. Ukraine is represented as an individual country. In addition, selected other economies that are major Ukraine trade partners (e.g. EU, UK, Türkiye) or are large economies in general (e.g. US, China, India, Brazil) are represented as individual countries in the developed aggregation (Table A3). The aggregation of sectors places great emphasis on the energy carriers: coal, gas, oil (crude and refined) and a disaggregated power sector (coal, gas, oil, nuclear, hydro, wind, solar and other renewables), as well as energy intensive activities (e.g. cement, steel, aluminum, fertilizers, etc.). Some of the energy-intensive activities, in particular steel and aluminum, are also split into primary and secondary (recycling) streams (Table A4).

The simulations have a reference year of 2017, and the model is solved in variable time steps (2-3 years) through 2035.

Table A3: Regional concordance

	Aggregated code	Aggregated country/region name
1	UKR	Ukraine
2	E27	European Union
3	GBR	United Kingdom
4	USA	United States
5	CAN	Canada
6	BRA	Brazil
7	CHN	China
8	IND	India
9	TUR	Türkiye
10	ZAF	South Africa
11	MOZ	Mozambique
12	HYA	High-income Asia
13	XER	Rest of high-income Europe
14	ANZ	Australia, New Zealand and the Rest of Oceania
15	XAS	Rest of Asia and Pacific
16	XEC	Rest of Europe and Central Asia
17	XMN	Rest of Middle East and North Africa
18	SSA	Sub-Saharan Africa
19	XLC	Rest of Latin America & Caribbean

Table A4: Sectoral concordance

No.	Activities represented in the model	Disaggregated GTAP-CE activities
1	Agriculture (AGR)	Paddy rice (PDR), Wheat (WHT), Cereal grains nec (GRO), Vegetables, fruit, nuts (V_F), Oil seeds (OSD), Sugar cane, sugar beet (C_B), Plant-based fibers (PFB), Crops nec (OCR), Bovine cattle, sheep and goats, horses (CTL), Animal products nec (OAP), Raw milk (RMK), Wool, silk-worm cocoons (WOL), Forestry (FRS), Fishing (FSH), Processed rice (PCR), Sugar (SGR)
2	Ore mining (OXT)	Mining of iron ores (MOI), mining of aluminum (bauxite) ores (MAO), mining of copper ores (MCO), mining of other metal ores (MOO), Mining of other ores (MOO)
3	Coal (COA)	Coal (COA)
	Oil (OIL)	Oil (OIL)
4	Gas (GAS)	Gas (GAS), Gas manufacture, distribution (GDT)
5	Processed food (PFD)	Bovine meat products (CMT), Meat products nec (OMT), Vegetable oils and fats (VOL), Dairy products (MIL), Food products nec (OFD), Beverages and tobacco products (B_T)
6	Refined oil (P_C)	Petroleum, coal products (P_C)
7	N-fertilizer (NFT)	N-fertilizer (NFT)
8	P-fertilizer (PFT)	P-fertilizer (PFT)
9	K-fertilizer (KFT)	K-fertilizer (KFT)
10	Other chemicals (CHX)	Basic pharmaceutical products (BPH), Rubber products (RBR), Other chemicals (XCH)
11	Cement (CEM)	Cement (CEM)
12	Other non-metallic minerals (NMX)	Other non-metallic minerals (NMX)
13	Iron and steel – primary (ISP)	Iron and steel – primary (ISP)
14	Iron and steel – secondary (ISS)	Iron and steel – secondary (ISS)
15	Aluminum – primary (APP)	Aluminum – primary (APP)
16	Aluminum – secondary (APS)	Aluminum – secondary (APS)

No.	Activities represented in the model	Disaggregated GTAP-CE activities
17	Other metals, casting and recycling (XME)	Copper – primary (CPP), Copper – secondary (CPS), Other metals – primary (MPP), Other metals – secondary (MPS), Recycling - iron and steel (RIS), Recycling – aluminum (RAL), Recycling – copper (RCP), Recycling other metals (ROM), Metals casting (MEC)
18	Computers and electronics (ELQ)	Computer, electronic and optical products (ELE), Electrical equipment (EEQ)
19	Other manufacturing (XMF)	Textiles (TEX), Wearing apparel (WAP), Leather products (LEA), Wood products (LUM), Metal products (FMP), Machinery and equipment nec (OME), Motor vehicles and parts (MVH), Transport equipment nec (OTN), Manufactures nec (OMF), Paper products, publishing (PPP), Plastic primary (PLP), Plastic secondary (PLS), Plastic recycling (PLR)
20	Electricity transmission and distribution (ETD)	Electricity transmission and distribution (TnD)
21	Nuclear power (NUC)	Nuclear power (NuclearBL)
22	Coal power (CLP)	Coal power baseload (CoalBL)
23	Gas and oil power (GOP)	Gas power baseload (GasBL), Gas power peakload (GasP), Oil power baseload (OilBL), Oil power peakload (OilP)
24	Wind power (WND)	Wind power (WindBL)
25	Hydro power (HYD)	Hydro power baseload (HydroBL), Hydro power peakload (HydroP)
26	Solar power (SOL)	Solar power (SolarP)
27	Other power (XEL)	Other baseload (OtherBL)
28	Construction (CNS)	Construction (CNS)
29	Trade and warehousing (TRD)	Trade (TRD), Warehousing and support activities (WHS)
30	Transport services (TRN)	Water transport (WTP), Air Transport (ATP), Other transport (OTP)

II.1.3 Key model features

The ENVISAGE Model at its core is a recursive dynamic and global computable general equilibrium model (CGE) (van der Mensbrugghe, 2024). It follows the circular flow of an economy paradigm (Figure 2). Firms purchase input factors (for example, labor and capital) to produce goods and services. Households receive the factor income and in turn demand the goods and services produced by firms. And equality of supply and demand determines equilibrium prices for factors, goods, and services. The model is solved as a sequence of comparative static equilibria where the factors of production are exogenous for each time period and linked between time periods with accumulation expressions.

Production is implemented as a series of nested constant-elasticity-of-substitution (CES) functions, the aim of which is to capture the substitutability across all inputs. Three production archetypes are implemented. The first is for crops that reflects intensification of inputs versus land extensification. The second is for livestock that reflects range-fed versus ranch-fed production. The final, also referred to as the default, revolves largely around capital/labor substitutability. Some production activities highlight specific inputs (for example, agricultural chemicals/fertilizers in crops and feed in livestock) and all activities include energy and its components as part of the cost minimization paradigm.

Each production activity is allowed to produce more than one commodity—for example the ethanol sector can produce ethanol and distiller's dried grains with solubles (DDGS). And commodities can be formed by the output of one or more activities (for example, electricity). ENVISAGE therefore uses a different classification of activities and commodities. One of the features of the model is that it integrates the GTAP power data base that disaggregates GTAP's electricity sector ('ely') into 11 different power sources plus electricity transmission and distribution (Chepeliev, 2023). Though the database has both the supply and demand side for all 11 power sources, the aggregation facility permits the aggregation of electricity demand into a single commodity and the 'make' matrix specification combines the output from the different power activities into a single electricity commodity.

Income accrues from payments to factors of production and is allocated to households (after taxes). The government sector accrues all net tax payments and purchases goods and services. The standard preference function is based on the constant-differences-in-elasticity (CDE) utility function that is used in the core GTAP model (Hertel 1997 and Corong et al. 2017). Investment is savings-driven and equal to domestic saving adjusted by net capital flows.

Trade is modelled using the so-called Armington specification that posits that demand for goods are differentiated by region of origin. The model allows for domestic/import sourcing at the aggregate level (after aggregating domestic absorption across all agents), or at the agent-level. In the standard specification, a second Armington nest allocates aggregate import demand across all exporting regions using a representative agent specification. Note that a newer, though minimally tested version, allows for sourcing imports by agent—also known as the MRIO specification. Exports are modelled in an analogous fashion using a nested constant-elasticity-of-transformation (CET) specification. The domestic supply of each commodity is supplied to the domestic market and an aggregate export bundle using a top-level CET function. The latter is allocated across regions of destination using a second-level CET function.[27] Each bilateral trade node is associated with four prices: 1) the producer price; 2) the export border price, also referred to as the free-on-board (FOB) price; 3) the import border price, also referred to as the cost, insurance and freight (CIF) price; and 4) the end-user price that includes all applicable trade taxes (but before domestic sales or VAT taxes). The wedge between the producer price and the FOB price is represented by the export tax (or subsidy if negative) and the wedge between the CIF and end-user prices represents the import tariff (and perhaps other import related distortions). The wedge between the CIF and FOB prices represents the international trade and transport margins. These margins represent the use of real resources that are supplied by each region. The

[27] The model allows for perfect transformation, which is the standard specification in the GTAP model.

global international trade and transport sector purchases these services from each region so as to minimize the aggregate cost.

The model has two fundamental markets for goods and services. Domestically produced goods sold on the domestic market, and domestically produced goods sold by region of destination. All other goods and services are composite bundles of these goods. Two market equilibrium conditions are needed to clear these two markets.

The model incorporates four types of production factors: 1) labor (of which there can be up to 5 types); 2) capital; 3) land; and 4) a sector-specific natural resource (such as fossil fuel reserves). The model allows for regime switching between full and partial wage flexibility. Capital is allocated across sectors so as to equalize rates of returns. Aggregate land supply is specified using an asymptotic supply curve, with an upward bound that provides the maximum expansion. Land is allocated across activities using a nested CET specification. Natural resources are supplied to each sector using an iso-elastic supply function with the possibility of differentiated elasticities depending on market conditions.

ENVISAGE incorporates the main greenhouse gases—carbon, methane, nitrous oxides and fluorinated gases—as well as an additional set of 9 emissions, such as particulate matter and black carbon. Emissions are generated by consumption of commodities (such as fuels), factor use (for example land in rice production and herds in livestock production) and there are also process-based emissions such as methane from landfills.[28] A number of carbon control regimes are available in the model. Carbon taxes can be imposed exogenously—potentially differentiated across regions. The incidence of the carbon tax allows for partial or full exemption by commodity and end-user. For example, households can be exempted from the carbon tax on natural gas consumption. The model allows for emission caps in a flexible manner—where regions can be segmented into coalitions on a multi-regional or global basis. The model allows for countries/regions to be in multiple trading systems simultaneously—such as Europe's Emission Trading System (ETS). In addition to the standard cap system, a cap-and-trade system can be defined where each region within a coalition is assigned an initial emission quota.

Dynamics involves three elements. Labor supply (by skill level) grows at an exogenously determined rate. The aggregate capital supply evolves according to the standard stock/flow motion equation, i.e. the capital stock at the beginning of each period is equal to the previous period's capital stock, less depreciation, plus the previous period's level of investment. The third element is technological change. The standard version of the model assumes labour-augmenting technical change – calibrated to given assumptions about GDP growth and inter-sectoral productivity differences. In policy simulations, technology is typically assumed to be fixed at the calibrated levels. Detailed documentation of the ENVISAGE model is provided in van der Mensbrugghe (2024).

II.1.4 Key baseline assumptions

Macro assumptions

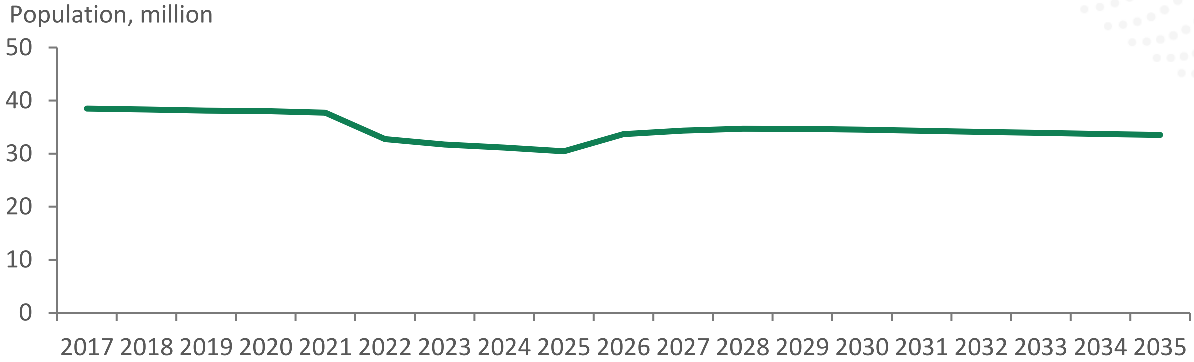
The demographic projections for Ukraine take into account the movement of refugees and are derived from the Ptoukha Institute for Demography and Social Studies (PIDSS) of the National Academy of Sciences of Ukraine. Labor force growth is equated with the growth

[28] The current version of the model is not tracking carbon emissions linked to changes in the land use and forestry activities.

of the standard working-age population (those aged between 15 and 64). Growth across labor skills (unskilled and skilled) is assumed to be uniform. For other countries/regions in the model, the population forecast is derived from the Shared Socioeconomic Pathways (SSP) database version 3 (2024 release), in particular, the SSP2 'middle-of-the-road' scenario is used.

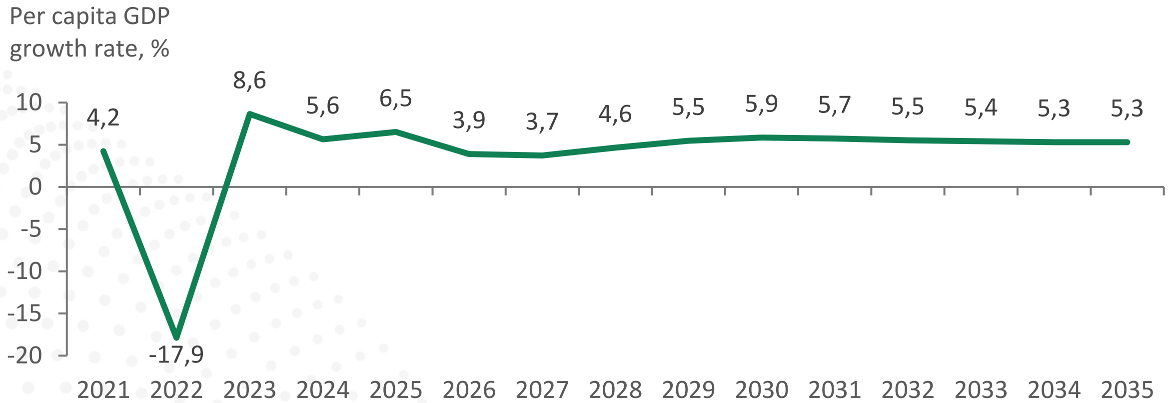
The chart below shows demographic assumptions for Ukraine over time (Figure A1). The reference year population for 2017 excludes the population of the temporarily occupied territories (Crimea and Donbas). A substantial decline in population over the 2022-2023 period reflects the movement of refugees from Ukraine, primarily to the European Union. An increase in population in 2026 corresponds to the assumption that the temporarily occupied territories will rejoin Ukraine in this year.

Figure A1: Population trends in Ukraine



The GDP projections for Ukraine are consistent with the macro forecast that has been used for the development of Ukraine's Low Emission Development Strategy (LEDS) draft. For other countries/regions, the GDP projections from the OECD SSP2 scenario are utilised. Per capita GDP and growth rates for Ukraine under the baseline scenario are depicted in Figure A2. After a substantial decline in 2022 following the Russian invasion of Ukraine, GDP growth rebounds in 2023 and then stabilizes in the long run at a rate of around 5%-6% per year. Reintegration of the temporarily occupied territories somewhat reduce the per-capita GDP growth rate during 2026-2027.

Figure A2: GDP growth projections for Ukraine, annual per capita growth rate (%)



Capital accumulation is generated by the standard neo-classical growth expression: current capital is equal to last year's depreciated capital plus last year's investments. Investment is savings-driven: private, public and foreign. The latter two are fixed at base year levels.

Private savings in the baseline adjust to smooth out changes to the aggregate rate of return to capital.

Productivity assumptions

The key productivity assumptions are divided into 3: (1) agricultural productivity is assumed to improve at a rate of 1% per annum (this is measured as output per hectare or yield), (2) energy efficiency is assumed to improve at a rate of 1%-2.5% across sectors and countries with higher productivity assumptions for developing countries, like Ukraine; and (3) labor productivity is targeted in the baseline to match the GDP growth projections. Labor productivity is held fixed in policy scenarios.

Energy technologies/preferences

These are broadly in three categories. The first is an autonomous electrification trend. For the case of Ukraine, the share of electricity is assumed to increase by 50% across the economy, while for the case of households and air transport, it is assumed to double. The shift in the electricity share is independent of changes in relative prices. Should electricity prices fall relative to other sources of energy, the increase in its share would be accelerated. The second is a downward trend in the price of renewable electric technologies—continuing trends seen over the last decade or two. The third is an autonomous non-price shift towards renewable power technologies. In the case of Ukraine, we assume that the renewable share in 2035 would be 21.4% following assumptions derived from the TIMES-Ukraine energy system model, which informs Ukraine's LEDS draft. A drop in renewable prices would accelerate these trends. Changes in these shares in the rest of the world are variegated across the modelled regions.

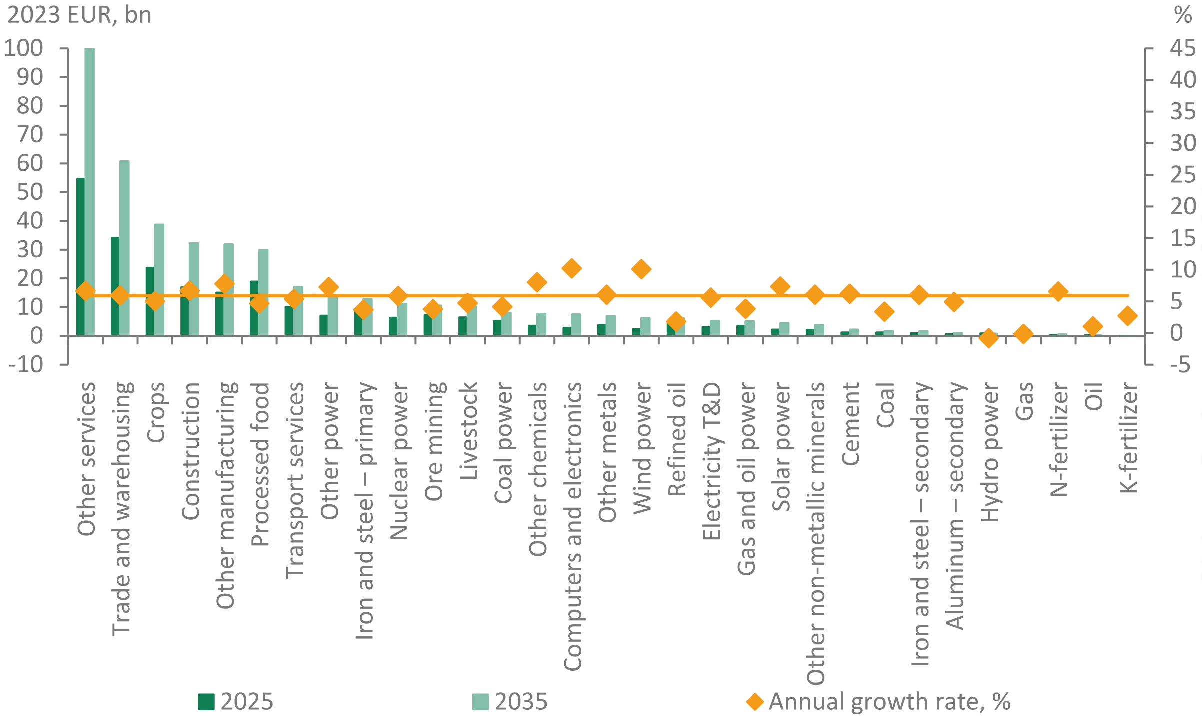
Energy and productivity assumptions for Ukraine discussed above are partly based on the Ukraine (draft) LEDS baseline scenario assumptions and partly are calibrated to reflect the baseline emissions trajectory used in LEDS. Carbon prices in Ukraine in the baseline scenario start at around 1.1 EUR/tCO_2 and increase by 7% per year (in real terms), reaching around 4.4 EUR/tCO_2 in 2035, aimed at broadly representing the continuation of the historical trends.

II.1.5 Key economic and environmental characteristics of the baseline

The structure of the output

The chart below shows the structure of output in the base and final year in the baseline scenario (Figure A3). The bars represent the level of output (measured in 2023 EUR, bn) and the diamond markers represent the average annual growth rate. The sectors are ordered according to the output share in 2025. Thus, the other services sector, which has a 22% share in the reference year, sees an absolute increase of around 49 EUR billion between 2025 and 2035. This sector also observes growth of 6.7% per annum, which is around 1 percentage point higher than the national average output growth rate over the same period – 5.9% (Figure A3). Other important sectors include other manufacturing and trade, crops and processed food. The construction sector grows at a pace above the national average growth rate, supporting the reconstruction efforts. Renewable generation activities increase their share in the generation mix and thus also grow at a relatively high pace. Fossil-fuel-supplying sectors see a moderate decline over time.

Figure A3: Output by sectors in Ukraine, 2025 and 2035

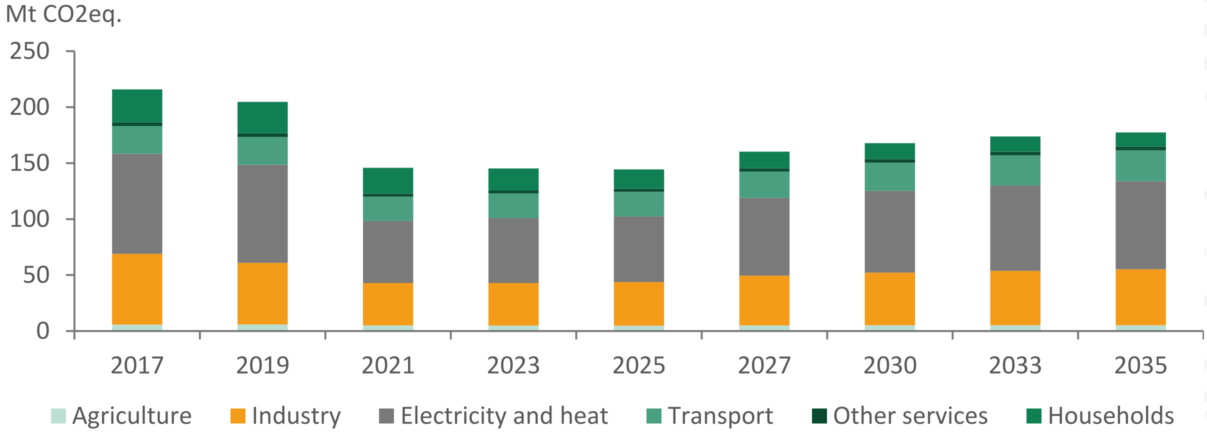


Emissions

Within the baseline scenario, there is a major decline in CO_2 emissions during 2022-2023, so that by 2025 emissions are substantially lower than the pre-war levels (Figure A4). As the Ukrainian economy begins to recover in the longer-run, emissions start growing; however, even by 2035, they do not reach the levels of 2017-2021. By 2035, CO_2 emissions are around 18% lower compared to the reference year level (i.e. 2017). This overall trend is consistent with the estimates of the emission trends from the TIMES-Ukraine model that underlie Ukrainian LEDS draft, as the latter suggest around 19% decline in emissions in 2035 w.r.t. 2017 under the baseline scenario.

In absolute terms, substantial emission reductions are coming from electricity and heat generation, driven by an increasing share of carbon-free technologies, including solar and wind. Emissions in industrial sectors also see a decline in absolute terms over time. Emissions from final consumption (households) fall, as consumers switch more toward electricity and substitute other fuels (gas for heating and petroleum for private transport). These trends should be considered in the context of baseline scenario assumptions, which do not reflect any ambitious mitigation efforts.

Figure A4: CO_2 emissions under the baseline scenario in Ukraine



Baseline scenario assumptions for other countries

Since we utilize a global model in the current study, which covers 18 countries and regions in addition to Ukraine (Table A3), baseline scenario assumptions need to be developed for the economies in the rest of the world. This includes both socio-economic assumptions, as discussed above, as well as energy and environmental dimensions. In the latter case, it is assumed that all countries/regions achieve their stated Nationally Determined Contributions (NDCs) by 2030 and continue the corresponding level of effort post-2030 (i.e., till 2035). No carbon prices are assumed in the countries, unless the country already implements a carbon price (e.g. Canada, EU, UK, etc.).

In the case of EU, it is assumed that the region achieves Fit-for-55 mitigation targets by 2030, further increasing mitigation ambitions by 2035 in line with achieving a 90% reduction in emissions (w.r.t. 1990) in 2040. The EU ETS carbon prices are: 69 EUR in 2027, 102 EUR in 2030, and 150 EUR in 2035, based on Prognos (2025) – for simplicity we assume ETS1 prices equal to ETS2 prices (all values in 2023 EUR). See Annex III.2 for a more thorough explanation. The share of free allocations in ETS1 starts at 80% in the reference year, then gradually declines over time (by 2035) based on the available forecasts.

II.2 Methodology distributional assessment

The analysis relies on the microdata of Ukraine's 2016 Household Budget Survey (HBS).[29]

As a first step, household income and expenditure on energy items (electricity, natural gas, district heating, and road motor fuels) are adjusted using the OECD-modified equivalence scale. As a second step, the 2016 HBS data are rescaled so that the averages of household income and total expenditure are consistent with the 2017 CGE benchmark data. This ensures comparability between the household survey and the model baseline.

To project future household income, growth rates from a representative household in the CGE model are applied to 2016 incomes. Future expenditures by good or service are derived by combining 2016 expenditure levels with expenditure growth from the CGE model, aligning HBS expenditure categories with the CGE groups (see Table A2). The CGE model captures household responses to changes in nominal income, the overall price level, and relative price shifts across goods and services, etc. Therefore, the implicit assumption is that income and price elasticities are uniform across households, regardless of their income level.

[29] Unfortunately, a more recent microfile for the HBS was not available to the author at the time of writing.

Note that reported 2016 expenditures by energy item are net of housing and utilities subsidies (HUS) and benefits. At the time, the HUS has been a relatively broad-based support mechanism with 34.6% of households enrolled in the scheme during the 2016/2017 heating season.[30] While the HUS does not perfectly target nor sufficiently cover low-income or otherwise vulnerable households[31] it does contain progressive design elements and has been relatively successful in reducing energy poverty in the context of the drastic 2015/2016 energy tariff reforms while maintaining incentives for energy efficiency and energy conservation.[32] Therefore, when estimating future energy expenditures, we implicitly assume that HUS subsidies cover an equivalent share of the total energy bill to 2016 levels. On the one hand, HUS rules have been tightened in the past years since 2016, reducing the coverage. Increased income in future years would further reduce HUS coverage since eligibility thresholds and total subsidies depend on household income. On the other hand, energy price increases such as those assumed for future years would mechanically increase the HUS coverage again due to the design of the HUS, as subsidies depend on the total cost of normative[33] (not realised) energy consumption. Thus, the assumption of a constant share of the total energy bill being covered by HUS across time and scenarios, based on the 2016 realised share per household, is a justifiable simplification that is agnostic of any future adjustments to the HUS design. Since the effect on energy expenditures and income burden of households are the variable of interest, we could not fully ignore the role of HUS, but detailed recommendations for design changes to the scheme are beyond the scope of this paper and might be subject of a future analysis.

[30] Berlin Economics (2021). *EEF support for HUS recipients: Conceptual ideas and quantitative estimations for a revolving mechanism*. (unpublished)

[31] Midões, Catarina (2021). *The Ukrainian Housing and Utilities Subsidy (HUS): Targeting and Coverage*. Low Carbon Ukraine Policy Evaluation. (Link)

[32] Alberini, A., & Umapathi, N. (2024). *What Are the Benefits of Government Assistance with Household Energy Bills? Evidence from Ukraine*. The Energy Journal, 45(3), 223-250. (Link)

[33] Depending on household size, dwelling surface area, etc.

Annex III

III.1 Mechanics of CBAM and implications for carbon tax levels

CBAM, the EU's carbon border adjustment mechanism, aims to reduce the risk of carbon leakage for certain goods subject to the EU Emissions Trading System (ETS1), replacing the system of free allocation of allowances. From January 2026, EU importers of steel, cement, aluminium, fertilisers, electricity, and hydrogen have to purchase CBAM certificates at the weekly average price of EU ETS1 allowances for the embedded emissions of the imported goods.

However, discounts apply to adjust for the free allocation of allowances in the EU ETS1 and for carbon prices effectively paid in the country of origin. For those goods where the free allocation of allowances is phased out gradually from 2026 to 2034, the share of embedded emissions subject to CBAM charges is phased in gradually throughout the same time period, meaning that the free allocation adjustment gradually converges to zero until 2034.[34] The following formula describes the calculation of the embedded emissions subject to CBAM:

$$Actual\ embedded\ emissions$$

$$-\ CBAM\ benchmark * CBAM\ factor$$ free allocation adjustment

$$-\ \frac{Carbon\ price\ effectively\ paid}{CBAM\ certificate\ price} * actual\ embedded\ emissions$$ paid carbon price adjustment

CBAM benchmarks are based on EU ETS1 benchmarks to reflect the logic of free allocations in the EU ETS1.[35] EU ETS1 benchmarks are derived from the emissions intensity of the 10% best performing installations per category and regularly adjusted. The CBAM factor (see annual values below) is defined as a "factor reducing the free allocation [of allowances]".[36] in the EU ETS1 and equally applies for the free allocation adjustment under CBAM.

Table A5: CBAM factor per year

2026	2027	2028	2029	2030	2031	2032	2033	2034
97.5%	95%	90%	77.5%	51.5%	39%	26.5%	14%	0

[34] For electricity, the full share of embedded emissions is subject to CBAM charges immediately from 2026 as the free allocation of allowances is already phased out. Furthermore, CBAM charges for electricity are largely based on default values instead of actual verified emissions.

[35] CBAM benchmarks are adapted and combined from EU ETS1 benchmarks because of different levels of granularity. While EU ETS1 benchmarks apply to installations/processes, CBAM benchmarks apply to imported goods classified by CN code.

[36] European Parliament, & Council of the European Union. (2024). Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community (consolidated version 01.03.2024). (Link) Art. 10a, para. 1a.

Thus, in an example for an imported good with actual embedded emissions of 1.2 tCO_2/t and a CBAM benchmark of 1 tCO_2/t, an importer in 2026 (assuming no carbon price paid) would have to purchase CBAM certificates for 1.2 – 1*97.5% = 0.225 tCO_2 per ton of imported product. In 2030, with the same actual embedded emissions, CBAM benchmark and (still) no carbon price paid in the country of origin, the importer needs to purchase CBAM certificates for 1.2 – 1*51.5% = 0.685 tCO_2 per ton of imported product. If, in the same year and for otherwise equal assumptions, a carbon price has effectively been paid in the country of origin at the relative level of half of the CBAM certificate price [37], the importer only needs to purchase CBAM certificates for 1.2 – 1*51.5% – ½ * 1.2 = 0.085 tCO_2 per ton of imported product.

This example illustrates how the introduction of a carbon price in the country of origin, such as Ukraine, can reduce the CBAM payments accruing to the EU budget for exports to (imports in) the European Union. However, it also demonstrates that there is no carbon price path that can reduce CBAM costs to zero across all goods exported to the EU, since the share of embedded emissions subject to CBAM (and thus the CBAM cost) depends on the actual embedded emissions, which varies by producer. For the special case of relatively clean producers with embedded emissions equal to the benchmark, setting a carbon price equal to the EU ETS1 price adjusted by 1 – CBAM factor (see table below) would reduce CBAM costs to zero. However, any imported goods with actual embedded emissions above the CBAM benchmark would still be subject to CBAM costs for the difference between actual embedded emissions and the benchmark (as long as the carbon price effectively paid is below the CBAM certificate price). Since embedded emissions for products from Ukraine are generally higher than CBAM benchmarks (which are derived from EU ETS1 benchmarks, based on the 10% best-performing installations per category in the EU ETS1) it is advisable to start with a somewhat higher level of carbon prices for the initial years than the price path in the table below in order to 'capture' a higher share of CBAM payments for goods with embedded emissions above the benchmark for Ukraine's government budget. It needs to be pointed out, however, that setting an optimal carbon price path 'capturing' the majority of CBAM payments is not an exact science due to the wide variation of actual embedded emissions vs. benchmark levels across different goods and producers.

Table A6: Carbon price path with zero CBAM cost for producers with emissions at the benchmark (EUR/tCO_2)

	2027	2028	2029	2030	2031	2032	2033	2034	2035
Assumed EU ETS price [38] (EUR/tCO_2)	69	81	92	102	112	122	132	141	150
CBAM factor	95%	90%	77.5%	51.5%	39%	26.5%	14%	0	0

[37] For example, with an EU ETS1 = CBAM certificate price of 100 EUR/tCO_2 and a carbon price effectively paid in the country of origin of 50 EUR/tCO_2.

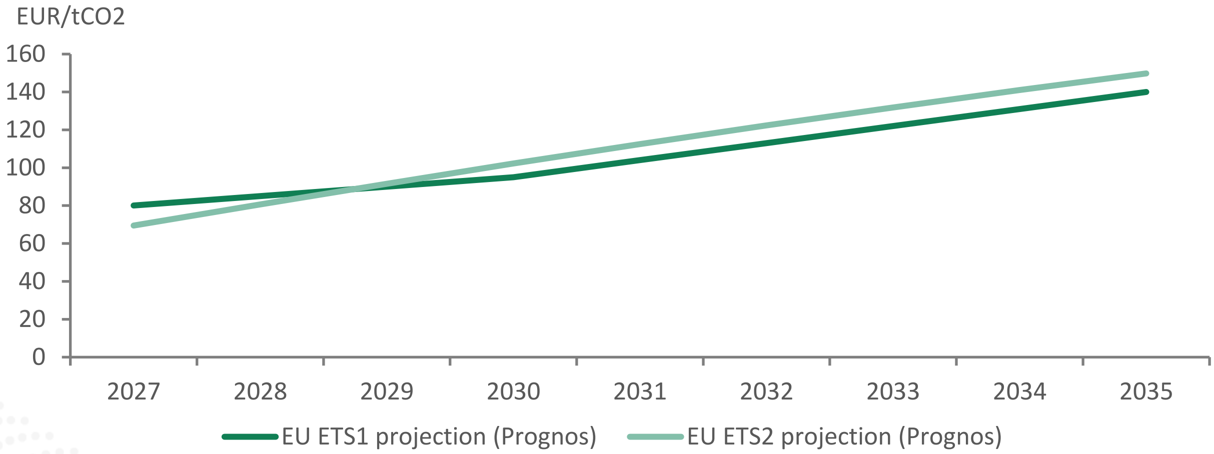
[38] Same assumption for EU ETS prices as throughout the study

Carbon price path[39] (EUR/tCO_2)	3	8	21	50	69	90	113	141	150

III.2 Discussion of assumed EU ETS allowance prices

Please note that the source used for EU ETS allowance price projections (Prognos, 2025) provides projections for EU ETS1 and ETS2 allowance prices (see Figure A5 below). ETS2 prices are expected to be lower in 2027 with 69 EUR/tCO_2 (ETS1: 80 EUR/t CO_2), but this flips in 2030 (ETS1: 95 EUR/t CO_2; ETS2: 102 EUR/t CO_2) and thereafter, with ETS2 allowance prices expected slightly higher than ETS1 allowance prices. Since the model used in this study cannot neatly differentiate between ETS1 and ETS2 sectors (for example, larger industrial plants are in ETS1 but smaller ones from the same industrial subsector can be in ETS2) we need to choose one price assumption across both ETS1 and ETS2. We chose ETS2 prices across the entire study since this study focusses on the topic of carbon tax reform, covering (mostly) the sectors under the scope of EU ETS2. Implicitly, we thus assume that EU ETS1 allowance prices also follow the same price trajectory.

Figure A5: EU ETS1 and ETS2 allowance price projections (Prognos, 2025)



[39] EU ETS price * (1 – CBAM factor)

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