SELECTED HIGH-IMPACT MEASURES

A revision of Ukraine's Carbon Tax

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Low Carbon Ukraine

Implemented by

Berlin Economics

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

Motivation and project background

This policy proposal is part of a series which was elaborated in the framework of the project Low Carbon Ukraine (LCU) supporting more ambitious paths for selected energy and climate policy areas.

The idea to develop the present ten "Policy Proposals" arose in the course of LCU's support for the Ministry of Energy of Ukraine in setting up a National Energy and Climate Plan for Ukraine. While Ukraine's climate targets are partially very ambitious, we often observed a lack of underlying analysis and concrete policy measures to achieve those targets. For the most crucial topics, we provide a comprehensive analysis and propose concrete policy measures based on international experience.

Each Policy Proposal was written in a multi-stage process: a first draft of LCU experts or invited professionals was discussed over summer and early autumn 2020 with Ukrainian experts and stakeholders. Results of those discussions were taken into account when updating the Policy Proposals. It is important to note, that the presented results reflect the view of the authors and not necessarily the position of the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety).

We hope that the present analysis and proposals will contribute to a fruitful and constructive discussion and help Ukraine to develop ambitious, yet realistic energy and climate policies.

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Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy. It is part of the International Climate Initiative (IKI) and is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on the basis of a decision adopted by the German Bundestag. The project is implemented by BE Berlin Economics GmbH.

ACKNOWLEDGEMENTS

We thank all participants in our stakeholder and expert workshops in June 2020 for their critical reflections and helpful comments. A special thank goes to Mr. Ben McWilliams who conducted an external review of this paper.

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Executive Summary

Among the countries that implemented a carbon tax, Ukraine's carbon price is one of the lowest. Studies have shown that it was virtually ineffective in strengthening energy efficiency and reducing carbon emissions, thus it does not support meeting international climate obligations. The country's current efforts to introduce a range of measures to achieve emission reduction goals call for a revision of Ukraine's carbon pricing strategy.

To avoid possible border-tax adjustment effects from the EU, we propose a price consistent with projections of the EU carbon price for 2030. Consequently, in the following, the implications of a carbon tax of EUR 39 /tCO_2 are discussed.

A poorly designed carbon tax can have negative effects on employment, competition and economic growth. Therefore, the OECD advises to respect the following principles: The carbon price should be phased-in over time in a predictable manner to support long-term investment decisions. The carbon policy should be transparent and fair. And it should be supplemented by measures that address the policy´s income effects as well as additional measures to support deeper emission reductions over time. In line with these recommendations, a gradual phase-in of the tax, starting in 2022 with a rate of EUR 4.3 /tCO_2 is suggested.

Further, supplementing measures are proposed. Experiences from other countries have shown that a (nearly) revenue neutral tax is commonly successful in reducing emissions without negatively affecting welfare. Therefore, the majority of tax income generated should be used to finance tax cuts or subsidies for households and businesses. These measures could be in the form of:

i. Support for the Housing and Utilities (HUS) scheme. By increasing energy prices, the carbon tax would automatically lead to an increase in subsidies under the current HUS scheme. Therefore, a share of the tax revenue should be dedicated to the Ministry of Social Policy for the HUS. Due the progressive nature of the programme, this would especially target low-income households.

ii. A reduction in indirect taxes, for example in the form of expanding the coverage of a reduced VAT rate. This could offset price increases in goods other than energy.

iii. A decrease in business taxes to reduce the burden carried by firms.

For the latter two, a separate, detailed assessment is required to identify the most efficient way of offsetting financial distress for consumers and producers. We do not propose legal earmarking but suggest political earmarking of revenues.

Within the first nine years after its introduction, in total, EUR 34.4 bn of carbon tax revenue can be redirected via these measures, with the highest annual tax revenue of EUR 6.2 bn achieved in 2030.

Still, the carbon tax should be regarded as only one piece of an effective climate package. To enable the price effects desired by setting a carbon price signal, a share of the tax revenue should be used to fund further projects targeting emission reductions. Therefore, this policy proposal constitutes only the first part of a series of 10 proposals, which altogether would likely have a high impact on Ukraine's climate action.

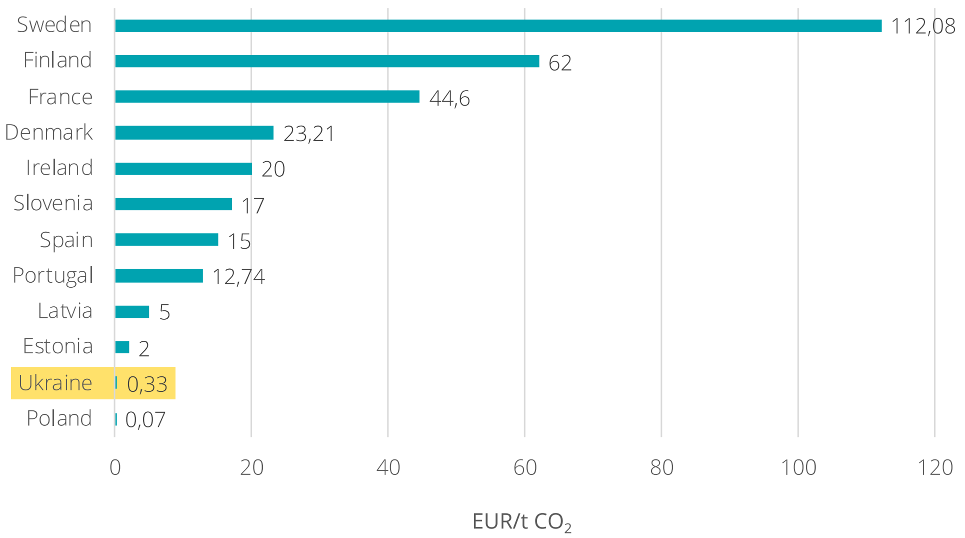
Current Carbon Taxing

Ukraine already has a carbon tax in place. But its rate is one of the lowest among countries that impose a tax on carbon.

Carbon pricing is a policy instrument that can induce broad, cross-sectoral climate mitigation measures. Ukraine's current carbon tax is part of the environmental tax, defined by Article 14.1.57 of the Tax Code (CMU, 2010). The tax rates for emissions by stationary sources are set by Article 243. The legislation targets emissions into the atmosphere, water and soil. The GHG taxes cover nearly all stationary sources of emissions, including the power sector and the metal, chemical and food industry. However, the carbon tax rate, which targets the largest share of GHG emissions, is too low to stimulate companies to implement energy saving or fuel switching technologies. Further, a lack of proper accounting, interaction of public authorities and control over pollution allowed eligible taxpayers to avoid paying the tax in past years (Romanko, 2018).

The tax was introduced in 2011 with a rate of EUR 0.003 /tCO_2 and was gradually increased by a rate not much higher than inflation until 2019 when a larger increase was implemented. Figure 1 displays carbon taxes (only taxes, not emission permit prices) in EU countries compared to Ukraine. With a carbon tax of EUR 0.33 /tCO_2 (as of 2019), Ukraine has one of the lowest carbon prices worldwide (World Bank, 2020). In comparison to other European countries, Ukraine is well below the median of EUR 17 /tCO2. Only Poland's tax rate was lower in 2019, with EUR 0.07 /tCO2. [1]

Figure 1: Carbon tax rates (excluding ETS) in Europe and Ukraine, as of 2019



Source: World Bank (2020)

Previous and current tax rates are too low to ensure consistency with the 1.5°C goal set by the Paris Agreement.

The National Ecological Centre of Ukraine (NECU, 2010) finds that the previous, low carbon tax rate does not lead to a reduction in the combustion of coal and associated carbon emissions. Frey (2016) further finds that the overall effects of the carbon tax were negligible. Despite the recent increase in the tax rate, Ukraine's current policy pathway would still lead to an emission level substantially exceeding levels required to maintain global warming below 2°C by 2030 – even when planned policies are taken into account (CAT, 2020). Moreover, the current carbon tax only covers stationary sources of emissions. The mobile sources diesel and gasoline are covered by an energy tax, which is however the lowest in Europe (Capros, 2020).

Effects of the harmful emission level are already noticeable. In 2016, Ukraine had the highest mortality from air pollution worldwide with up to 66'000 people dying annually because of air pollution (Heinrich Böll Foundation, 2019). Additionally, longer-term effects of climate change, like extreme weather conditions, have a negative impact on the country's agricultural sector (Polityuk, 2020). As these events are likely to become even more frequent and more extreme, this calls for a more ambitious carbon pricing and consequently a revision of Ukraine's carbon tax.

[1] Note, that large emitters in the EU (incl. Poland) fall under the EU Emission Trading System featuring prices around EUR 20/tCO2 in 2019.

Background info

Carbon Pricing in the EU

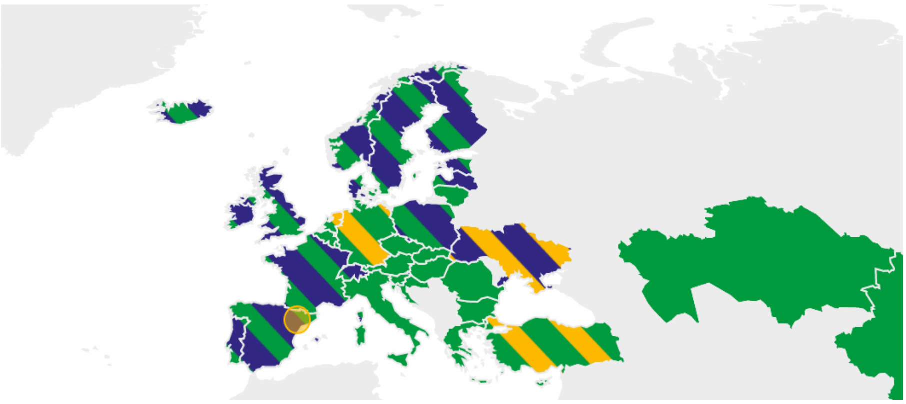
The Nordic countries are frontrunners in terms of carbon pricing. They introduced a carbon tax in the early 1990s. Their decision was built on ambitions to reduce income taxes and on their concerns about climate change. By both lowering income taxes and putting a price on carbon, they achieved a mainly revenue-neutral taxing scheme (Andersen, 2010). Soon after, the Netherlands and Slovenia followed. Since then, Portugal, Spain, Ireland, the UK, Poland, Latvia,and Estonia have also introduced carbon taxes, while the rest of the EU is covered by an ETS (see Figure 2).

Apart from different carbon tax rates, the countries' approach also differs in revenue recycling. Sweden and Finland lowered direct income taxes. Denmark and the UK on the other hand aimed at reducing inflationary pressure by lowering employer's social security contributions. Additionally, they contribute a share of their carbon tax revenue (5-20%) directly to energy efficiency subsidy programs. The Dutch similarly introduced a combination of both. In the first phase, they reduced income taxes, while lowering employers´ payroll and corporate taxes in the second phase.

In the EU-funded COMTER project Andersen (2010) found emission reductions of 6% in the period of the mid 1990s to 2004 under the early-movers, which can be attributed to the carbon tax. The results from the E3ME model, presented in Barker *et al.* (2009), lie in the same range. They attribute reductions of 4-6% of emissions to the carbon tax in the Nordic countries and of 2% in the Netherlands.

The difference can be explained by less ambitious tax shifts in the Netherlands. By investigating the mentioned EU countries, Hájek *et al.* (2019) find evidence that the long-term carbon tax in place in these countries is environmentally efficient (Was genau bedeutet das?). Further they find that a ceteris paribus increase of the carbon tax rate by one Euro per ton of CO_2 equivalent, would reduce per capita GHG emissions by 11.58 kg per year.

Figure 2: Carbon pricing in Europe



- ETS implemented or scheduled for implementation
- Carbon Tax implemented or scheduled for implementation
- ETS or Carbon Tax under consideration
- ETS and Carbon Tax implemented or scheduled
- ETS implemented or scheduled, ETS or Carbon Tax unter consideration
- Carbon tax implemented or scheduled, ETS under consideration

Source: World Bank (2020)

Proposed carbon pricing mechanisms

Carbon prices intend to internalise the costs of pollution imposed on society by the "polluter pays" principle and hereby incentivise low emission behaviour. The low level of effectiveness of Ukraine's current carbon tax, however, calls the existing carbon pricing regime into question. Before a revised taxing scheme is proposed, different options of carbon pricing are therefore discussed.

In economic theory, an ETS is the first best policy choice if transaction costs are sufficiently low. As these are rather high in reality, a carbon tax presents an attractive, second best choice.

Two carbon pricing designs can be differentiated. Either, prices can be set directly by the lawmaker in the form of a carbon tax. Based upon this price, the level of carbon emissions will be determined by emitters. The lawmaker can also set quantities – in the form of caps – instead of prices. This is achieved through establishing an Emission Trading System (ETS). By this, the lawmaker has direct control over the amount of carbon that is allowed to be emitted. The carbon price is then determined by the demand for emission certificates. The Coase Theorem states that an ETS is the first best policy choice when externalities are tradable and transaction costs are sufficiently low (Capros, 2020). In reality, transaction costs can be rather high, such as: 1) Better-informed market participants may exploit information problems , leading to extra profits for those participants, 2) there is a risk of market power abuse, which poses a serious threat in Ukraine as large emitters usually highly influential and 3) uncertainty in prices makes it harder to foresee consequences and to offset negative effects (Andrew, 2008). A poorly designed ETS can thus encourage revenue-shifting to dominant players as well as a reduction in confidence of investors. A tax can be implemented more credibly and could hereby support Ukraine to attract capital. Despite being only the second-best policy choice, the arguments in favour of a carbon tax are simplicity, transparency and reduced regulatory uncertainty. Moreover, it could help Ukraine to act sooner than later, as a carbon tax requires less time for implementation than an ETS.

Previous studies favouring a downstream tax or an ETS in Ukraine, failed to take it's administrative challenges and disadvantages into account.

Different projects have already evaluated potential carbon pricing strategies for Ukraine. The 'Preparedness for Emissions Trading in the EBRD Region I' (PETER I) evaluates how the current carbon tax can be improved while PETER II prepares a road map for a transition towards an ETS. For an improved carbon tax they propose a scheme with two tax bands. They neglect, however, mobile sources and rely on the current downstream[2] tax (EBRD, 2014). The Partnership for Market Readiness (PMR) compares different scenarios: a carbon tax, an ETS and a combination of a tax and an ETS (Vivid Economics, 2019). They find that an extended carbon tax covering all sectors has a larger negative effect on output and competitiveness than the ETS with similar emission reductions. However, they neglect the addressed institutional drawbacks of an ETS. While a carbon tax leads to larger costs for companies, it might provide easier access to capital to improve efficiency and install less emission-intensive technologies. Moreover, as in the EBRD (2014) study, the IPMR neglects the transport sector, which makes up 10% of Ukraine's emissions (see the chapter on transport policies). The most recent study by Kantor & E^{3}M (2021) evaluates carbon pricing for Energy Community Contracting Parties, including Ukraine. Kantor & E^{3}M (2021) propose the introduction of a cap-and-trade system in the power and heat sector, while country's could consider a carbon tax in the transport and building sector. The authors assess different policy options for this cap-and-trade system and conclude that a scenario encompassing a transitional period for carbon pricing and integrated power and gas markets with the EU presents the best policy option.

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[2] A downstream approach taxes actual emissions.

Ukraine needs to establish plans for an ETS to meet obligations under the Ukraine-EU Association Agreement (icap, 2020). As a first step towards an ETS, in December 2019, a law on Monitoring, Reporting and Verification (MRV) of greenhouse gases (GHG) was adopted and should come into force in 2021 (CMU, 2019b). However, establishing an ETS is connected to a high administrative burden, as credible institutions have to be set up and market manipulation needs to be countered. As the design should be well thought-through, the implementation might take some time. Nevertheless, Ukraine should act rather sooner than later which is why this Chapter focuses on the easier-to-implement measure – an upstream carbon tax. In the long-run though, this should be complemented by an ETS to meet international obligations (see *Background Info – Transition to ETS* on page 11).

We prpopose an easier-to-implement upstream carbon tax, which should be complemented by an ETS to meet international obligations.

This paper further focuses on CO_2 emissions from the combustion of fossil fuels. These can be covered by levying an excise tax on coal, natural gas, oil and their derivatives. The point of taxation determines the distinct point in the supply chain the tax is raised. An upstream approach taxes the carbon content in raw fuels, whereas a midstream approach taxes fuels further down the supply chain and a downstream approach taxes actual emissions. In theory, the approaches should lead to equal results, at least in the "perfect" economic world (Hardistya *et al.*, 2019). However, there are several advantages of an upstream approach over the downstream tax, most of all its administrative simplicity and the broad coverage of fuels. With an upstream approach, the fuels are taxed at the point of extraction or importing, i.e. when entering the market. This has the following implications for different fuel types: Crude oil would be taxed as it reaches the refinery, natural gas as it enters the pipeline system, or if it bypasses the system[3] when it arrives at the end user and coal as it leaves the mine (Horowitz *et al.*, 2017). There can also exist a hybrid form, where coal and natural gas are taxed upstream, oil, however, is taxed midstream i.e. as it *leaves* the refinery. Consequently, different oil products, like gasoline, diesel and kerosene, are taxed differently and the different carbon intensities are accounted for. Further, imports of fossil fuels would be taxed whereas exports of coal, natural gas or oil products would be eligible for refundable tax credits. In comparison to the current downstream taxing scheme in Ukraine, an upstream/midstream approach reduces the administrative burden of accounting actual emissions in production processes. Moreover, when the tax is charged at the point of market entry, the collection of the tax might be easier than with the current scheme. Disadvantages of an upstream carbon tax are that it is less flexible and that it is more complex to exempt certain sectors – notably the ETS sectors once the market has been established. Still, some countries show that it is possible. France, Denmark and Sweden each apply an upstream carbon tax successfully exempting ETS sectors (World Bank, 2017).

Under the proposed upstream tax, fuels are taxed when they enter the market, which reduces the administrative burden in comparison to the current downstream tax.

Introducing a substantial carbon price in Ukraine could lead to carbon leakage, which means that a carbon tax imposed in Ukraine could lead to an increase in emissions in other jurisdictions. In theory, this could result if consumers turn to producers from countries where no tax is applied, as these face lower input-costs especially for carbon-intensive products, such as steel, electricity, or cement. To avoid a shift from locally produced goods to imports, a border carbon adjustment could be implemented. A standard border carbon adjustment corresponds to an estimation of how much higher goods prices would be, if the same carbon tax was applied in the country of production. It would apply the carbon tax to imports, based on an estimation of how much GHGs are emitted during the production of these products. This, however, is connected to high computational efforts, high administrative burden and legal risks. Moreover, there is no empirical study showing carbon leakage to actually occur and whether the carbon tax could not even have positive effects in the long-run through increased competitiveness (World Bank, 2017). Furthermore, the two most important trading partners of Ukraine, Europe and China, already imply (at least partly) a price for carbon in the form of emission trading schemes. Therefore, the benefits of introducing a border tax adjustment might be small.

Carbon border adjustments are connected to high computational efforts, while its positive effects are debateable.

[3] e.g. when large gas consumers are directly connected to gas extraction or landing points.

With the proposed uniform, upstream tax on fossil fuels exports would be eligible for exemptions. No carbon border adjustments are proposed. The steel sector would be eligible for partial exemptions, due to its importance for the economy and its vulnerability towards the tax.

Based on the presented arguments, a change of Ukraine's current downstream tax to a hybrid upstream-midstream, uniform carbon tax is proposed, where coal, peat and natural gas are taxed when they enter the market, whereas oil is taxed as it leaves the refinery, i.e. oil products are taxed when they enter the market. To allow for a clear distinction to the current downstream approach, where actual emissions instead of the carbon content is taxed, only the term 'upstream' will be used in the following. The tax would not be applied to biofuels. Furthermore, imported fuels would be taxed, whereas exported fuels would be eligible for exemptions. In law, the tax could be expressed in normal trade units (weight or volume), based on average, internationally acknowledged CO_2 emissions. No border tax adjustment for processed commodities or electricity is suggested.

Summarising, the tax would cover all sectors. This can be justified 1) by an equity point of view – by taxing all sectors, the "polluter pays" principle is preserved – and 2) by the significant administrative burden that would be required to exempt certain industries. Nonetheless, if the carbon tax faced by a certain sector, e.g. agriculture[4], would lead to a substantial negative effect for the population while the overall positive effects of taxing this sector are negligible, a tax refund could be discussed. This applies to the steel sector. Its exports accounted for 23% of Ukraine's total output in 2018, thus representing an important part of Ukraine's economy (German Advisory Group Ukraine, 2019). Moreover, it is strongly exposed to the world market, as the majority of the steel is produced for export. In addition to the lack of market-ready technologies that would allow for producing low-carbon steel as well as to the lack of innovation, this sector is especially vulnerable to the CO_2 tax and would lose its competitiveness with a carbon price of EUR 16 /tCO_2 (see chapter "Towards a decarbonisation of Ukraine's steel sector"). Exemptions could also be granted to companies that install carbon capture and storage technologies.

To avoid border adjustments from the European side, a tax corresponding to EU ETS price projections of EUR 39/tCO_2 in 2030 is proposed, which should be phased-in linearly over 9 years.

To avoid that Ukraine itself is affected by possible future carbon border adjustment mechanisms of the EU, the price for future ETS-sectors should be set in accordance with EU prices. To ensure consistency between sectors and to maintain the simplicity of a uniform tax rate, this is proposed to be applied to all sectors. The reference carbon price is retrieved from the updated ETS price trajectory of the EUCO3232.5 policy scenario[5] from the European Commission (2019). However, this scenario still assumes a 40% reduction in GHG emissions by 2030. As most recently European emission reduction goals have been revised to 55% below 1990 levels by 2030, a different price could result. Once a new policy scenario is published, the carbon price target should be updated. Until then, we calculate with the price stated in the EUCO3232.5 policy scenario of EUR 28/ tCO2 by 2030 in 2013 prices. Assuming a 2% inflation, this results in a carbon price of EUR 39/ tCO2 in 2030. To allow for a smooth adaption of consumer and producer behaviour, a linear phase-in is suggested, starting with a rate of EUR 4.3/ tCO2 in 2022[6]. To ensure that Ukraine complies with international obligations, a road map for a transition to an ETS is presented in the box. The steel sector is proposed to be partly exempted so that it is covered by an effective carbon tax of EUR 1.3/tCO_2 in 2022 and reaches EUR 39/ tCO2 in 2050 (see the chapter on decarbonising the steel sector for more details on the reasoning).

[4] A carbon tax faced in agriculture would increase prices for food, which could have a regressive effect. It should be evaluated with the help of appropriate models, if this is the case for Ukraine.

[5] The EUCO3232.5 policy scenario takes a renewable energy target of 32% and an energy efficiency target of 32.5% into account (European Commission, 2019).

[6] Given that changes to the current carbon tax law need to be made, 2022 is a more realistic starting point than 2021.

[B1] Alternatively, the steel sector could be granted a share of free allowances, where the share would decrease continuously. However, we deem that certainty about future prices is important in attracting investments in the sector, which is why a predetermined carbon tax trajectory is proposed instead.

Under the presented proposition, Ukraine's carbon pricing would be broader and more ambitious than in other Eastern European countries. It might even seem too ambitious, given its economy being among the weakest. Still, there are arguments in favour of this approach; If the tax revenue is efficiently used and redistributed, there should be no or minimal, negative effects on GDP (World Bank, 2017). In contrast to an ETS with free allowances, a simple, (nearly) revenue neutral carbon tax efficiently returns revenues to the economy. At the same time it ensures that the whole economy (not just some sectors) takes the costs of pollution into account. To reduce the tax burden, actors are incentivised for efficiency improvements, which can increase competitiveness and might help Ukraine to achieve a competitive advantage over countries that act later on climate-related issues. Moreover, the broad and ambitious tax would avoid locking-in emission-intensive technologies, that might lead to a competitive disadvantage in the future.

The broad and ambitious tax could grant Ukraine a competitive advantage in the long-term.

Background info

Transition to ETS

We propose a longer transition period than proposed by Vivid Economics (2019) to reduce institutional risks associated with an ETS. Moreover, an introduction with fixed price allowances is suggested:

1. Until 2025, the monitoring and reporting of emissions in MRV-sectors is tested and improved.
2. From 2025, fixed price allowances (as in the testing phase of Australia): MRV sectors are required to purchase allowances at a fixed rate which is set in accordance to the carbon tax rate. An unlimited amount of allowances is issued and MRV sectors are eligible for tax exemptions. The steel sector could be excluded from purchasing allowances and instead continue to be taxed with the reduced tax rate[B1].
3. After 2030, allowances will be gradually limited. A floor price could be set to maintain predictability of prices. Allowances are auctioned, while the steel sector is excluded and still covered by the carbon tax. An upstream carbon tax also remains in place for non-MRV sectors. The tax rate could either follow a separate trajectory or be set as an average ETS price of the previous year (as in Portugal). The latter ensures consistency between MRV and non-MRV sectors but could result in higher uncertainty as well as difficulties in budget planning for redistributive measures.

Apart from different carbon tax rates, the countries' approach also differs in revenue recycling. Sweden and Finland lowered direct income taxes. Denmark and the UK on the other hand aimed at reducing inflationary pressure by lowering employer's social security contributions. Additionally, they contribute a share of tax revenue (5-20%) directly to energy efficiency subsidy programs. The Dutch introduced a combination of both. In the first phase, income taxes were reduced, while employer's payroll and corporate taxes were reduced in the second phase.

In the EU-funded COMTER project, Andersen (2010) found emission reductions of 6% in the period of the mid 1990s to 2004 under the early-movers, which can be attributed to the carbon tax. The results from the E3ME model, presented in Barker *et al.* (2009), lie in the same range. They attribute 4-6% emission reductions to the carbon tax in the Nordic countries and 2% in the Netherlands. The difference can be explained by less ambitious tax shifts in the Netherlands. By investigating the mentioned EU-countries, Hájek *et al.* (2019) find evidence that the long-term carbon tax in place in these countries is environmentally efficient. Further they find that a ceteris paribus increase of the carbon tax rate by one Euro, reduces per capita GHG emissions by 11.58 kg.

Supporting measures

Efficient revenue recycling is crucial to avoid negative effects on the economy

The broader macroeconomic implications of a carbon tax depend on its design. A poorly designed carbon tax can have negative effects on competitiveness, employment and economic growth. Also, it can lead to higher price levels, due to higher fuel prices. Consequently, a carbon tax should be accompanied by supporting policy measures such as revenue recycling, which means to funnel the state's tax income back to citizens.

I. Compensation programmes

Producers are likely to pass a share of increased input costs on to consumers. The magnitude of the amount forwarded to consumers commonly depends on the sensitivity of demand to price changes, i.e. the price elasticity of demand. Additionally, environmental taxes that increase prices for heating and electricity tend to affect low-income households more than high-income households, because low-income households typically spend a larger share of their income on energy than richer households. This is termed 'regressive'. The effect can be counteracted by using a share of the carbon tax revenue to reduce the burden on low-income households. This can for example be achieved through a progressive[7] decrease of income taxes (Kosonen, 2012).

A commonly cited effect in combination with income tax relaxation, is the tax interaction effect, first presented by Bovenberg and de Mooij (1994). They show theoretically that the increase in fuel prices could lead to a loss in workers' purchasing power, despite income tax relaxation. This in turn would lead to lower labour supply or higher salary demands, in turn causing inflation.

Revenues could be returned by lowering income tax or VAT, whereas the option with the least distortion effects should be selected. It should be complemented by a reduction in corporate taxes.

To counteract this effect, cuts in labour costs can be implemented, for example in the form of reduced employers' social security contributions. Ekins and Barker (2003) argue that when the reduction in payroll taxes offsets the net increase by an environmental tax, a pass-over of increased fuel prices to product prices will not be necessary, thus labour market effects can be prevented. Another way of preventing an increase in product prices is to reduce indirect taxes, like the value added tax (VAT). Reducing payroll taxes and reducing indirect taxes can both lead to a so-called ´double dividend´ effect, where a distortionary tax is replaced by a tax, which corrects a market failure like the carbon tax (World Bank, 2017). Which one of the two options could reap the most benefits is, however, country-specific. A first assessment could be done by estimating the marginal costs of the different taxes.

The OECD (2015) argues that attributing only a portion of the tax revenue to targeted income tax adjustments is sufficient to counter negative effects on low-income households. This is proven by the example of British Columbia. The upstream carbon tax in British Columbia is perceived as the closest to the ideal carbon tax among economists (Metcalf, 2019). Here, the carbon tax is nearly revenue neutral. A combination of corporate and personal income tax cuts, low-income tax credits and targeted corporate as well as personal income tax credits ensured that a significant reduction in GHG emissions could be achieved with negligible effects on overall economic activity (Murray and Rivers, 2015).

Consequently, tax shifting programmes should consist of measures targeting progressive tax shifts for households as well as measures to decrease the burden carried by firms.

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[7] The terms regressive/progressive are commonly used in connection with taxes. For a regressive tax, the relative burden of households *decreases* with income, i.e. low-income households spend a larger share of their income on the tax. On the contrary, for a progressive tax, the relative burden for households *increases* with income, thus high-income households spend a larger share of their income on the tax than low-income households. This principle can also be applied to tax relief programs. If such a program is progressive, the relative relief for low-income households will be larger than for high-income households.

It should be kept in mind that a carbon tax is a transitory tax. Once CO_2 emissions have been reduced substantially, the government's revenue stream may dry out. Thus, constant monitoring is required, and the government needs to be able to shift back to the preceding system. Frequent monitoring additionally presents the advantage that compensation mechanisms can be adjusted so that revenue neutrality is maintained[8]. This can help to improve transparency and the political acceptance of the carbon tax, as it is emphasised that the goal of the tax is not to create additional revenue streams but to reduce emissions.

The carbon tax is a transitory tax and revenues may dry out when CO_2 emissions shrink.

II. Households

In Ukraine, a mechanism that could help to protect low-income households is already in place, namely the Housing and Utilities Subsidies (HUS) scheme. It has demonstrated its ability to counter effects of energy price hikes in the wake of gas price reforms (ESMAP, 2016). The HUS is a targeted social assistance programme and is one of the main mechanisms of social security in Ukraine, especially with regard to costs of energy (Ministry of Social Protection Ukraine, 2020). A detailed assessment of how the HUS works and an exemplary calculation is given in chapter 6.3 of the Annex. Under the programme, costs for housing services, utilities (gas, power, heat and water) as well as administrative costs are subsidised for households that pay more than a certain share of their income for these services. In 2019, 37% of households received housing subsidies (Ukrstat, 2020).

Low-income households in Ukraine are protected by the Housing and Utilities Subsidies (HUS) programme.

The subsidy is decoupled from actual consumption. By consuming less energy, a household would have to pay less for energy with receiving the same amount of subsidy. Hereby, households are incentivised to achieve efficiency improvements. Also, a higher share of the bill is covered for low-income households. By its progressive design, the programme helped protect vulnerable groups of the population from the price increase of natural gas and district heating and thereby had a substantial impact on poverty.

The programme can support the implementation of a carbon tax in the same way. As the payment within the social norm is influenced by energy prices, the subsidy will increase with a rise in energy prices. Low-income households are protected from price changes of electricity and heating. Still, it should be evaluated whether an adjustment of the formula for the share of contribution is required to maintain the HUS's effectiveness.

Furthermore, households would only be protected from rising electricity and heating prices, but not from any other price increase – energy or non-energy. Frey (2016) proposes a decrease in indirect taxes for Ukraine, which constitutes the largest position in government income (Ministry of Finance of Ukraine, 2020). With a VAT of 20%, Ukraine is at the lower end in comparison with other European countries. But other countries commonly have a broader application of reduced VAT rates for specific products. Ukraine only lowers its VAT for pharmaceuticals. Thus expanding reduced VAT rates to more products could be an option in the country. However, as explained in the previous section, the most efficient revenue recycling can be achieved by reducing the most distortionary taxes. Thus, first an analysis on the marginal costs of different taxes should be carried out.

Further measures are required to protect low-income households from price hikes of non-energy products.

[8] In British Columbia, for example, the Ministry of Finance is required to develop a plan that ensures revenue-neutrality each year. If the target is not met, a penalty in the form of salary reduction can be placed upon the minister.

III. Businesses

An assessment in close consultation with the Ministry of Finance is required to find efficient ways of reducing a carbon tax's burden for businesses.

To avoid negative labour market or investment effects, not only households but also businesses should be reimbursed. Studies often find that corporate income taxes are among the most distortionary (Marron and Morris, 2016). Reducing corporate income taxes, however, presents certain difficulties in Ukraine. A large informal sector and undeclared work pose a problem in Ukraine. Consequently, the corporate profit tax revenues are low in relation to international standards, despite its rate of 18%, which is well in the range of other European countries. In the 2020 budget, the corporate income tax only makes up for 6.5% of total revenue from income taxes – 93.5% is accounted for by the personal income tax (Ministry of Finance of Ukraine, 2020). An alternative option to decrease the burden for businesses is in the form of reduced employer social security contributions. Nonetheless, a shift away from labour taxation has already been addressed in past reforms. Since 2016, the social security contribution was significantly reduced. Now employers are liable for a single contribution of 22% of the gross earnings of employees. Before the reform, a share of 3.6% had to be carried by the employee, while the employers' share ranged from 36.7%-49.7% (IMF, 2016).

In order to make a well-informed decision on the most efficient way of reducing the carbon tax's burden for businesses, an assessment in close consultation with the Ministry of Finance of Ukraine should be performed. A first high-level assessment based on an input-output multiplier approach by Kantor & E³M (2021) implied that targeting support to trade exposed firms might be superior to generally lowering taxation or labour costs in Ukraine.

IV. Other measures

A share of the revenue can be used to fund low-emission measures.

Besides tax-shifting programmes, a share of the carbon tax revenue should be used to support energy projects. For example, with assistance programmes for transport and the energy performance of buildings, the welfare of low-income households can be improved. Further, targeted programmes that remove hidden costs and risks for energy efficiency projects, increase the responsiveness of consumers to the carbon price signal and thus support consumers and producers to switch to low carbon fuels and/or technologies (OECD, 2015). Policies should, however, be market based, i.e. not favour specific technologies, to leave room for adaption (Andersen, 2010). Moreover, an efficient carbon pricing policy requires the existence of competitive market structures to pass on costs. In the case of Ukraine, this is especially relevant in power and gas markets. In both markets, final consumer prices should be market-based and reflect actual costs.

The following measures, which are covered in separate chapters, are proposed:

i. Phase-out of energy subsidies;

ii. Further liberalisation of the gas and electricity market;

iii. Energetic retrofitting of buildings;

iv. Coal sector transition.

Political – but no legal – earmarking is desirable.

Due to the volatile political setting in Ukraine, earmarking for both redistributive and energy efficiency/fuel switching measures might be required. Earmarking is the political or legal commitment to use revenues from specific sources for specific purposes. Rather political than legal earmarking is desired here as it ensures efficiency and political support but at the same time allows to determine each year anew, how revenues can be used most effectively. For a detailed discussion on this topic see Saha, Poluschkin and Kirchner (2019).

Assessment of Carbon Tax Effects

The methodology with which the effects of a carbon tax of EUR 39 /tCO_2 on Ukraine's tax revenue, carbon emissions and consumer costs are evaluated, is presented in the Annex. The following results take short-run as well as long-run price sensitivities of energy demand into account. The short-run sensitivities reflect consumers' immediate response to higher energy prices within one year. In the long-run, these responses are likely to be more pronounced as they take gradual changes in the capital stock over several years into account (Huntington, Barrios and Arora, 2019). The time scope of the expression "long-term" is not predefined, though and varies between studies. It should allow for the time necessary to do significant capital investments, i.e. several years. Here, we define the long-run as 3 years, as in Deryugina, MacKay and Reif (2017). However, this should be seen as a lower bound and depending on the sector, adjustments might take considerably longer. Furthermore, it should be noted that only price effects are considered here and no income or substitution effects.

The effects of the tax are evaluated with short- and long-run price sensitivies of demand.

I. Tax revenue

A revision of Ukraine's carbon tax to an upstream tax with a phase-in of a tax rate up to EUR 39 /tCO_2 in 2030 is proposed. For a smooth implementation of the final target, a tax of EUR 4.3 /tCO_2 should be levied on all fossil fuels in 2022 and increased linearly by the same rate of EUR 4.3 /tCO_2 each year afterwards.

Under the upstream approach, each fuel is taxed at the point of entry into the economy. Consequently, primary energy is taxed. Due to different implications for consumer prices, in this analysis it is still differentiated between consumption of primary energy of natural gas, coal and oil and the consumption of secondary energy like electricity and heat. Fuels like coal and gas used for the production of heat and electricity are deduced from primary energy consumption. Consumption data from the energy balance from Ukrstat (2020) is used as an initial starting point, while assumptions about future energy demand are adopted from Scenario 2 of Ukraine's draft NDC[9]. Figure 3 displays the annual revenue from the carbon tax.

With an initial tax rate of EUR 4.3 /tCO_2 in 2022, a tax revenue of EUR 905 m is generated. This increases to EUR 6.2 bn in 2030, when the full EUR 39 /tCO_2 are levied. In total, EUR 34.4 bn are generated in the period from 2022 to 2030.

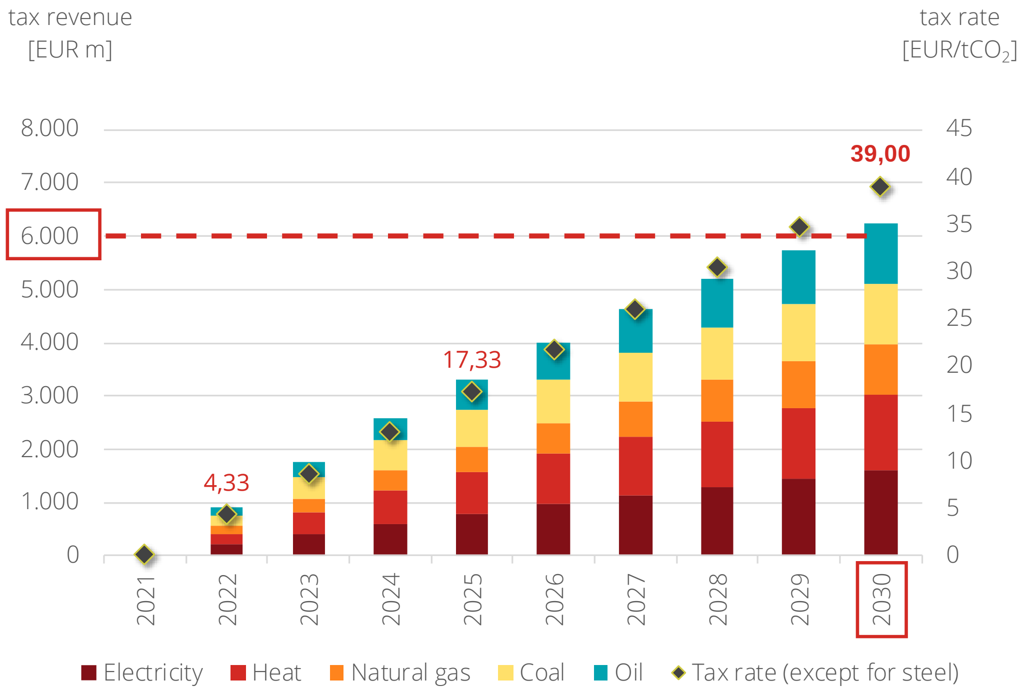
EUR 34.4 bn could be raised in tax revenue over nine years.

Revenues from heat and electricity consumption exceed those from natural gas, despite higher total energy consumption of natural gas. Even though carbon neutral energies account for the majority of power production, the carbon emissions per energy output is higher than per primary energy input, because losses occur when thermal energy is transformed to electrical energy. The same holds for heat production. Here however, a larger share of energy is produced from coal or gas. The third largest source of revenue is coal due to its high carbon content and due to its importance for Ukraine's industry in steel production.

Revenues resulting from secondary energy consump-tion constitute the largest share.

[9] The NDC2 Scenario assesses the impact of a timely implementation of all existing legislation as well as drafted climate related legislation. It implies a 1% increase in coal demand, a 36% increase in electricity demand and a 22% increase in heat demand compared to 2019 levels. Gas demand is specified to fall by 23% and oil demand by 20%. In the NDC2 Scenario, only the currently implemented carbon tax is taken into account. Its effects on energy demand can be neglected due to its low value.

Figure 3: Approximately 6 bn EUR carbon tax revenues by 2030



Source: Based on Own calculation

II. Effects on CO_2 Emissions

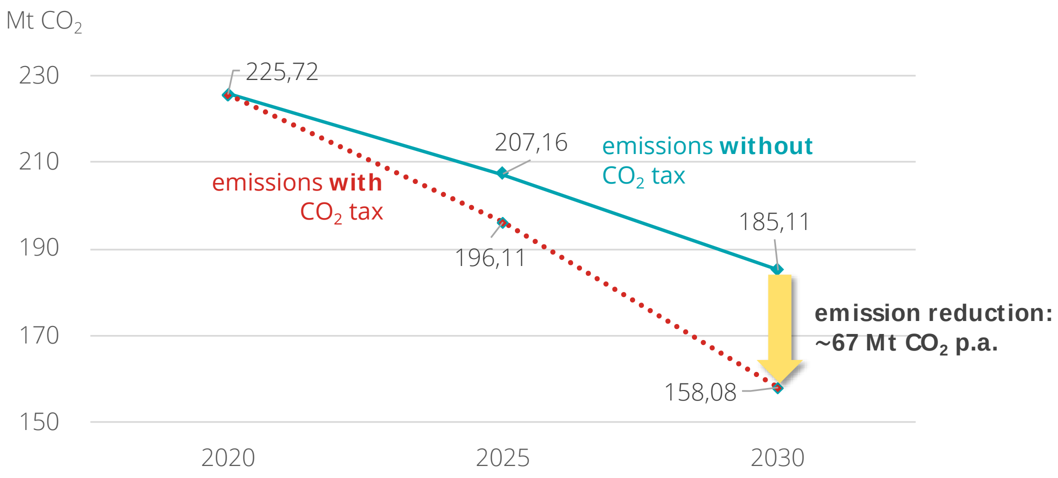
Emission reductions are achieved through energy demand reductions in the short-run and efficiency improvements in the long-run. In total, 27 Mt could be saved over 9 years.

To evaluate the emission reduction potential two scenarios are compared: a reference scenario and a carbon tax scenario. The reference scenario is based on the 2nd policy scenario of the NDC. It takes the implementation of currently addressed policies into account (for more details see **Annex: Evaluating the impact of a carbon tax**). These would lead to a decrease in emissions. But planned and current measures are not sufficient to comply with the goal set in the Paris Agreement to keep global warming below 1.5 °C (CAT, 2020). A revised carbon tax can support the reduction of CO_2 emissions.

The dotted line in Figure 4: Carbon tax would lead to an additional decrease of CO2 emissions from fossil fuel consumption by 67 Mt p.a. represents CO_2 emissions under the carbon tax scenario. The difference between the two scenarios results from the decrease in energy consumption and long-run efficiency improvements induced by the internalisation of emission costs. As energy demand is rather price inelastic in the short-run and the carbon tax is introduced with a low rate of EUR 4.3 /tCO2, this difference is rather small in the beginning. After four years, 11.0 Mt can be saved compared to the NDC2 scenario. In 2030, an emission reduction potential of 27.0 Mt could be realized.

Coal consumption contributes the most to CO_2 emission savings. On the one hand, this is because of the high emission factor of coal, which causes a comparably higher increase in fuel prices. On the other hand, this effect is caused by the comparably higher price sensitivity of coal demand. This leads to a reduction in coal demand by up to 40% in 2030 under the carbon tax scenario, compared to a baseline scenario.

Figure 4: Carbon tax would lead to an additional decrease of CO_2 emissions from fossil fuel consumption by 67 Mt p.a.



Source: Own calculation

Due to the underlying price assumptions, which are based on the NDC, that coal prices decrease by 7% while gas prices increase by 37% until 2030, the carbon tax does not lead to fuel switching in the electricity sector. Under these assumptions a carbon price of EUR 58 /tCO_2 would be necessary for gas to become cheaper as a power source than coal. Under the assumption that fuel prices stay constant at the 2020 level however, a carbon tax of EUR 25 /tCO_2 would be sufficient.

Under underlying fuel price assumptions, a carbon price of EUR 58/tCO_2 would be required for gas power to become cheaper than coal.

It should be noted that the discussed figures present rough estimates. The results heavily depend on assumptions regarding fuel prices, future energy demand and elasticities. Additionally, substitution effects were neglected in this analysis.

Consumer costs

With an upstream tax, the tax authority does not decide on who pays the final price of the tax. The price increase through the carbon tax could be passed forward to consumers, backward to producers, or shared between both, depending on the price elasticity of demand. Therefore, consumers likely do not only face an increase in energy prices themselves, but also an increase in prices of consumer goods. The two effects should be separated. First, the implications are different. For an increase in household's energy prices, the "polluter pays" principle can be applied. Here, the consumer can directly influence the level of emissions by investing into energy efficiency measures. This is not the case for consumer goods. Second, the compensation mechanism differs. While the increase in energy prices is mainly covered by the HUS (except for oil and oil products), the increase in consumer good prices requires other mechanisms, like the proposed changes to the VAT.

Under a carbon tax, consumers face higher costs from energy as well as non-energy products, as a share of the burden of firms is likely passed forward to customers.

I. Households

In this section, we analyse the consumer costs resulting from residential energy consumption. As energy demand is commonly very inelastic, it is assumed here that the price increase is passed forward to consumers for non-regulated as well as regulated energy markets. Even though prices for electricity are assumed to remain constant until 2030 (assuming Ukrainian energy subsidies stay in place), it is assumed that the increase in wholesale electricity prices through the carbon tax is passed on to end consumers. This implies that the government increases the politically determined price for regulated consumer groups by the carbon tax costs arising for the marginal power plant. The same holds for heat prices.

It is assumed that the costs of the carbon tax in energy and heat supply are fully passed on to consumers.

The price increase in electricity and heat present the largest burden for household.

The increase in household prices is determined by the carbon content of each fuel type. Coal prices increase more than oil or natural gas prices, due to the high emission factor of coal. However, the largest increase in the price per energy unit consumed has to be faced from electricity and heat consumption. Here, up to EUR 25 /MWh for electricity and EUR 15 /MWh for heat would need to be paid additionally, if a carbon tax was introduced. This can be traced back to high energy losses in the transformation process from coal and gas to secondary energy.

Households have to pay up to EUR 3 bn additionally for energy consumption, contributing 44% of the tax revenue.

Even though natural gas consumption exceeds electricity consumption, the latter makes up for a larger share of the increase in household expenditure (Table 1). Increased costs from electricity consumption contribute EUR 1.4 bn to the change in household expenditure on energy by 2030, which is more nearly half of the total costs of EUR 3.3 bn faced by households from direct energy consumption. This is followed by consumption of natural gas, oil and heat. Coal makes up only a minor share. In total, consumers contribute on average 44% to the revenue collected with the carbon tax.

Table 1: Increase in household expenditure for energy consumption (EUR m.)

Energy type	2022	2025	2030
Electricity	144	604	1418
Heat	65	234	422
Natural Gas	81	298	559
Coal	5	16	26
Oil/Oil products	71	264	517
Total	366	1’417	2’942
Tax revenue	904	3’323	6’234

Source: Own calculation

HUS compensation

Vulnerable households are protected by the HUS.

The HUS mechanism constitutes one part of the compensation scheme. It progressively protects households from increased electricity, heat and natural gas prices by subsidising a share of the costs, depending on the income. As the subsidy paid to households depends on energy prices, the compensation increases with the carbon tax. Consequently, households eligible for HUS will be protected from the price increase of residential energy consumption. As electricity, heat and natural gas make up around 80% of increased expenditure, this protects vulnerable households from the lion’s share of increased costs from energy consumption. In the Annex **(Housing and Utilities Subsidies)** it is explained in more detail, how the HUS works and how the compensation paid to households is calculated.

Figure 4 illustrates the costs for the government resulting from increased subsidies under the HUS as well as the number of households receiving subsidies. Fuel prices for 2025 and 2030 correspond to prices assumed in the NDC, based on the IEA World Energy Outlook 2018 (IEA, 2018). A summary is given by Table 2 in the Annex. In between those years, a linear increase is assumed. The annual 5% growth rate of income is based on the NDC Baseline Macroeconomic Scenario.

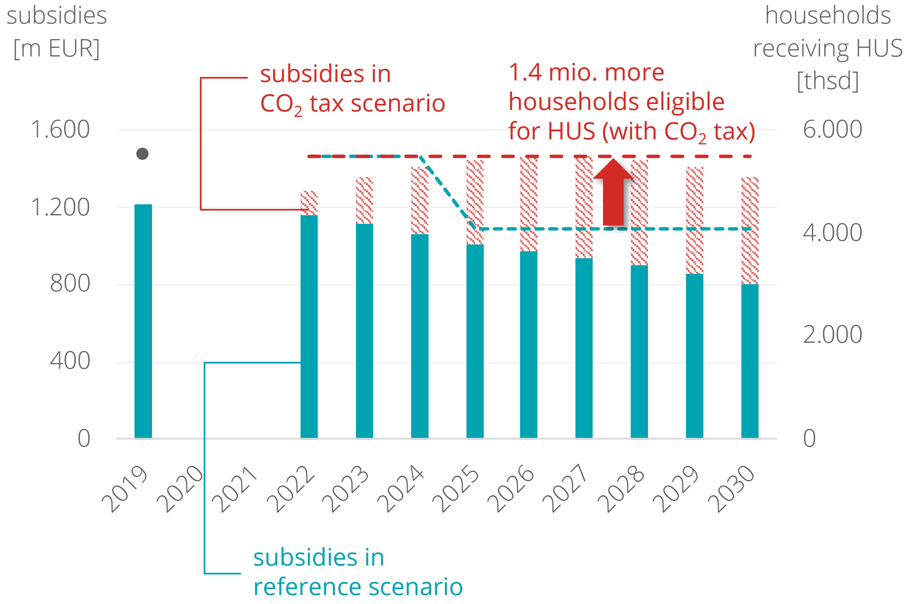
From 2027, the increase in household expenditure offsets increased costs from the tax.

The increase in household income results in a decrease in HUS paid under the reference scenario. Annual HUS would decrease from EUR 1.2 bn in 2019 to EUR 0.8 bn in 2030. Under the carbon tax, the costs of the HUS for the government would increase until 2027. After this year, the exponential growth in income offsets the linear growth in energy costs from the carbon tax. With EUR 1.4 bn, HUS payments would be only slightly above the 2019 payments by 2030.

By increasing the payment under the social norm (see the carbon tax also affects the number of households eligible for the HUS. In 2019, around 5.4 m households (37% of total) received subsidies. This would remain the same under the carbon tax scenario. For the reference scenario on the other hand, the number of households decreases to 4 m households. The number of households receiving subsidies does not decrease smoothly due to i) the definition of income groups as ranges, ii) the income distribution and iii) the progressive nature of the determination of subsidies. A detailed description on the income groups receiving subsidies as well as the amount of subsidies paid per income group can be found in Table 4 in the Annex.

The number of households eligible for the HUS would remain constant under the tax.

Figure 5: The CO2 tax would offset the drop in the number of households receiving subsidies (HUS) that would result from increased income



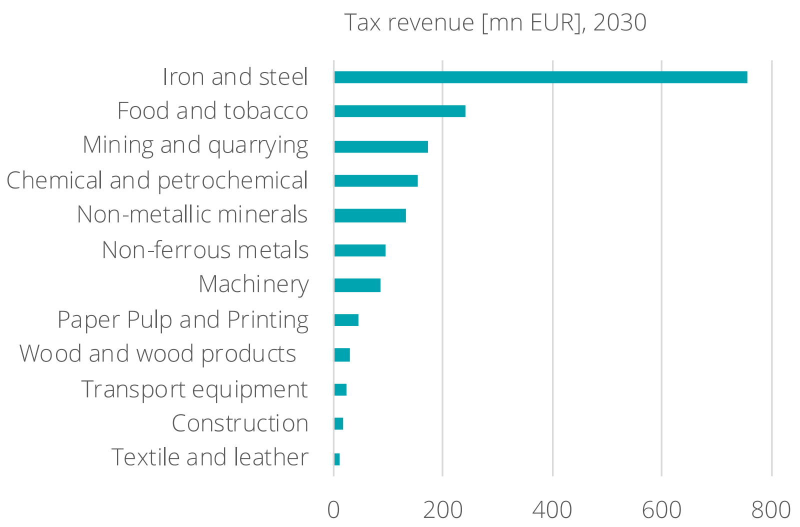
Source: Own calculation

II. Industry

Despite the reduced tax rate, the steel sector carries the largest burden.

The increase in household's energy expenditure represents only 44% of the tax revenue. 34 p.p. of the remaining 56% will be borne by the industry. Despite enjoying a lower tax rate, the majority of these costs are borne by the steel sector. Its costs increase from EUR 100 mn in 2022 to EUR 750 mn in 2030. The steel sector is followed by the food, the mining and the chemical industry (see Figure 6).

Figure 6: Iron and steel sector would pay significant amount of CO_2 taxes in 2030



Source: Own calculation

As previously explained, a share of the costs borne by the industry is likely to be passed forward to final consumers, depending on the price elasticity of demand. Thus, households will also face higher prices from consumer goods. Evaluating the overall costs for households should capture the effects on different industries in Ukraine, as the demand elasticity differs depending on the product. To take the interaction of supporting measures with the carbon tax as well as the interaction between different sectors into account, an assessment with the help of e.g. a constant general equilibrium model should be performed. This, however, would exceed the scope of this policy proposal and should be part of a separate assessment.

Employment effects

Employment effects in the past have been positive, but can be negative for specific emission-intensive industries.

Employment effects can be ambiguous and depend on the specific industry as well as on the design and revenue recycling of the carbon tax. In British Columbia, the revenue-neutral carbon tax led to an increase in overall employment (Yamazaki, 2017). Nonetheless, negative employment effects can arise for emission-intensive industries, for example the coal sector and the steel industry. Structural measures to support employers in the coal sector as well as in the steel industry are addressed in Policy Paper "A socially sustainable coal phase-out in Ukraine" (Zachmann, Temel, von Mettenheim, 2021).

Energy Efficiency

The carbon tax incentivises energy efficiency improvements through price signals. These effects are captured in this analysis by the long-run elasticity. The effects vary drastically between the different energy types. The least efficiency improvements are realised for electricity and petroleum consumption. Here, up to 4% of consumption are saved in the long-run. While electricity demand is very inelastic, this is not the case for petroleum (see Table 2 in the Annex). However, the price increase of gas and diesel induced by the carbon tax is comparably lower. By funding energy efficiency programs with tax revenue, a higher decline in energy consumption and consequently GHG emissions could be achieved. In the transport sector these could include the promotion of alternative engine technologies, by which the responsiveness of petroleum demand to the carbon tax would be intensified. Natural gas and heat consumption lie in the middle, with efficiency improvements of 8% and 9% respectively. Due to the internalisation of the high environmental costs, the largest efficiency improvements are realised for coal, with up to 40% in 2030.

The least efficiency improvements are expected for electricity consumption, the most for coal.

Research, innovation & competitiveness

The effects of carbon pricing on competitiveness can be adverse. In theory, carbon pricing leads to an increase in production costs, causing a disadvantage compared to countries without a carbon price. Given, however, that the price is set in accordance with Ukraine's largest trading partner – the EU – and that other countries are likely to follow, this effect might not be decisive.

A gradual phase-in should allow companies to adapt and help to counter negative effects on competitiveness.

Further, there is little empirical evidence that carbon pricing has actually led to reduced economic competitiveness in countries that have already introduced a carbon price. On the contrary, it provides a stimulus to diversify, innovate and invest. Still, this requires a smooth transition, thus a gradual phase-in is recommended, so that firms can adapt (World Bank, 2016). Additionally, a carbon tax can create a competitive advantage for low-emission companies, whereby more financial resources are attracted to these sectors.

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Annex: Evaluating the impact of a carbon tax

A carbon tax affects behaviour by increasing fuel prices. Therefore, at the heart of the evaluation of a carbon tax lies the determination of the increase in prices through the tax and the change in consumer behaviour due to this increase. From this, important figures on tax revenue, change in household expenditure and carbon emissions can be estimated.

I. Data

The calculations are based on assumptions about future fuel prices as well as assumptions about the carbon tax. Estimated fuel prices for the years 2020, 2025 and 2030 correspond to prices assumed in the NDC, based on the IEA World Energy Outlook 2018 (IEA, 2018). In-between, a linear increase is assumed. The carbon tax is also assumed to increase linearly until it reaches a final carbon price of 39 EUR/tCO_2 in 2030. A summary of fuel prices and the carbon tax rate for each year is presented in Table 2.

Table 2: Assumptions about energy demand and prices

			2022	2025	2030
natural gas	price [EUR/MWh]	residential	23.4	26.3	26.4
		non-residential	24.8	28.0	28.0
	demand [TWh]		150.9	141.5	125.8
coal	price [EUR/MWh]		9.4	8.9	9.2
	demand [TWh]		134.7	135.1	135.8
oil	price [EUR/MWh]		42.2	50.0	54.6
	demand [TWh]		138.2	127.7	114.6
electricity	price [EUR/MWh]	residential	35.0	35.0	35.0
		non-residential	62.5	62.5	62.5
	demand [TWh]		170.5	181.9	200.8
heat	price [EUR/MWh]	residential	36.3	40.0	46.2
		non-residential	38.8	45.0	47.3
	demand [TWh]		93.7	98.5	106.5
carbon tax	EUR/tCO2		4.3	17.3	39.0

Source: NDC and Own calculation

For coal and oil, the presented fuel prices correspond to consumer prices in the reference scenario. Natural gas prices, however, differ from raw fuel prices due to costs of transmission, distribution and supply. Further, it is differentiated between prices for households and non-households for gas as well as electricity.

Moreover, assumptions about fuel demand for the baseline scenario are required. For this, energy demand projections are retrieved from Scenario 2 in the NDC. The NDC Scenario 2 builds on the assumption that all legislation adopted as of September 1st, 2019, as well as drafted climate-related legislation will be implemented. Based on this scenario, the share of coal in electricity decreases from 35% to 18%, whereas the share of gas increases from 5% to 7%. In district heating, the policy focus of stimulating biomass heat production is captured, by which the share of renewables in district heat production increases to 35% in

2030. The exact composition of heat production is not specified. Here, it is assumed that coal will be phased-out completely, thus gas makes up for the remaining 65% of heat production.

Another key parameter in the calculations is the elasticity of demand. Unfortunately, there is a lack of reliable data for price elasticities of energy demand in Ukraine. This issue was also addressed by The World Bank (2005), who argues that average OECD elasticities can be used for Ukraine instead. Following this approach, average OECD elasticities for residential and non-residential demand are retrieved from Liu (2004). For heat, the same price elasticity as for residential natural gas demand is used.

Table 3 summarises the price elasticities for different energy types. The price elasticity of demand for each energy type is inelastic. The price elasticity of the electricity demand presents the lowest value, demonstrating that an increase in the electricity price is likely to have only very limited effects on demand, at least in the short run. Residential demand for gasoline presents a higher elasticity. This can be drawn back to the fact that for this energy it is easier to switch to alternatives. For high gasoline prices, consumers might switch to public transport for distances they would have travelled by car otherwise.

Table 3: Price elasticities of demand

Energy type		short-run	long-run
Electricity	residential	-0.03	-0.16
	non-residential	-0.01	-0.04
Natural gas	residential	-0.10	-0.36
	non-residential	-0.07	-0.24
Petroleum	residential (gasoline)	-0.19	-0.60
	non-residential (diesel)	-0.09	-0.17
Coal		-0.23	-0.40

Source: Liu (2004) and Burke and Liao (2015)

II. Methodology

a. Change in prices

Primary energy price increase

First, the increase in fuel prices needs to be calculated. It should be distinguished between primary and secondary energy consumption as there are different implications for prices. For both types, it is differentiated between two scenarios: Scenario 1 is a reference scenario without a carbon tax. Scenario 2 is based on the same assumptions as Scenario 1, but includes a gradual increase of the carbon tax.

By imposing a price on carbon, the prices of primary energy changes, depending on the amount of carbon emitted per energy unit consumed. Consequently, the increase in primary energy prices can be calculated, based on their carbon content:

$$P_{t,1} = P_{t,0} + CO_2\ content\ \times tax\ rate \tag{1}$$

The carbon content is based on emission factor assumptions in the Policy Oriented Tool for Energy and Climate Change Impact Assessment (POTEnCIA), retrieved from the JRC Integrated Database of the European Energy System (European Commission, 2020).

Electricity price increase

In the electricity consumed in Ukraine, there are two sources of emissions: coal and natural gas. The increase in power prices depends on the *marginal* power plant. If the marginal power plant is a coal-based plant, electricity prices will increase based on the carbon content of coal. If the marginal power plant is a natural gas-based plant, it will change on the basis of the carbon content of natural gas.

Currently, the marginal power plant is a coal-fired power station. This, however, depends on the marginal costs (MC) of power production. The marginal costs are not constant, but depend on plant efficiency, fuel costs and the carbon price.

$$MC = \frac{Fuel\ costs}{Efficiency} + \frac{CO_2\ content}{Efficiency} * carbon\ tax \tag{2}$$

It is assumed that coal-fired power stations have an efficiency level of 35%, while gas turbines are assumed to have an efficiency level of 45%.

Even though coal prices are assumed to decrease until 2030, while natural gas prices are assumed to increase, marginal costs of gas fall below those of coal when carbon prices reach a certain level. This can be explained by the higher efficiency of gas plants and by the lower carbon content of natural gas. When carbon prices reach a certain level, their costs outweigh the fuel costs. Under the previously mentioned assumptions, the marginal costs of coal are lower than those of gas. Only if the carbon price would be raised to EUR 58/tCO2 the marginal costs of coal would exceed those of gas by 2030.

c. Change in demand

Based on the fuel demand of the baseline scenario and after-tax prices, the change in demand due to the introduction of the carbon tax can be calculated. The methodology refers to Ouyang and Lin (2014). A constant-elasticity inverse demand function is assumed, as proposed by the (IEA, 1999):

$$q_t = {p_t}^{\varepsilon} \tag{3}$$

where q_t is energy demand in t, p_t the price for energy in t and ε is the price elasticity of demand. The change in demand can then be calculated by:

$$\Delta q_t = Q_{0,t} - Q_{1,t} \tag{4}$$

With

$$Q_{1,t} = exp\ (\varepsilon \times (ln\, P_{1,t} - ln\, P_{0,t}) + ln\, Q_{0,t}) \tag{5}$$

where the index 0 indicates that the quantity/ price corresponds to the baseline scenario without the carbon tax, while the index 1 indicates the quantity/ price corresponding to the carbon tax scenario levels.

The presented methodology can only account for a demand reduction in CO_2-intensive sectors. Frey (2016) demonstrates that a carbon tax can also lead to an increase in production of less carbon-intensive products. She uses a CGE model and finds that in Ukraine, raising the CO_2 tax could increase output in the textile industry, which hardly uses any fossil fuels as an input of production.

As there are different elasticities for residential consumers and non-residential consumers, it is distinguished between households and non-households.

Petroleum demand

In the energy balance of Ukraine, it is not differentiated between petroleum consumption from private and non-private cars. To evaluate the impact on household expenditure, it is however necessary to differentiate between these two categories.

To approximate this, wholesale as well as retail petroleum sales from Ukrstat (2020) are aggregated and multiplied by the share of private passenger cars of 0.9, 0.58 and 0.79 for gasoline, diesel and LPG respectively.

d. CO_2 emissions

Once the change in demand has been calculated, the difference in carbon emissions between Scenario 1 and 2 can be calculated by:

$$\Delta CO_2 = \textstyle\sum_t \Delta CO_{2,t}\ with\, \Delta CO_{2,t} = \sum_i \Delta q_{i,t} \times CO_2 EF_i \tag{6}$$

III. Housing and Utilities Subsidies

The HUS protects vulnerable groups of the population from energy price increases by subsidising a share of the utility bill exceeding a certain income share. While the subsidy depends on prices, it is detached from actual consumption. Due to this – and due to its recent monetisation – incentives for increasing energy efficiency and decreasing energy consumption are kept intact.

The subsidy (S) granted to a household is determined by the difference between the payment within the social norm (SP) and the share of contribution (Sh) multiplied with the household income (HI) (CMU, 2020b):

$$S = SP - Sh * HI$$

The social norm defines how much an average household would consume. It takes the equipment of a household into account. For example, for a household equipped with a stationary electric stove and centralised hot water the social norm defines an electricity consumption of 110 kWh per month per household with an additional 30 kWh for every other member of the household but not exceeding 230 kWh per month (CMU, 2019a) (see Table 4). The share of contribution is determined by the household income per capita (HI/N) and the subsistence level (SL) (CMU, 2020a):

$$Sh = \frac{HI/_{N}}{2 * SL} * 20\%$$

The calculation of the subsidy can be illustrated by the following example; With a subsistence level of UAH 1'700 and an average monthly income of a two-person household of UAH 4'000, the share of contribution would be:

$$\frac{UAH\ 4'000/_{2}}{2 * UAH\ 1'700} * 20\% = 12\%$$

A contribution payment of 12% * UAH 4'000 = UAH 470 would result. If the total bill for housing and communal services based on the social norm would amount UAH 1'500, a subsidy of UAH 1'500 – UAH 470 = UAH 1'030 follows.

The HUS covers expenses for electricity, gas, heat, cold and hot water, waste and building management. The social norm is defined by housing characteristics. Table 4 summarises the different increments for the relevant categories affected by the carbon tax, namely electricity, gas and heat.

Table 4: Social norm consumption

Category	Housing characteristics	base	additional for each person	max
Electricity [kWh/month]	no stove, centralised hot water	70	30	190
	electric stove, centralised hot water	110	30	230
	electric stove, no centralised hot water	130	30	250
	no stove, no centralised hot water	100	30	220
Heat [sqm]		62.52		
Gas [cm p.p.]	gas stove, centralised hot water	3.3		
	no gas stove, gas water heater	5.4		
	gas stove, gas water heater	10.5		

Source: (CMU, 2019a)

Consequently, to determine the increase in subsidies resulting from the carbon tax, knowledge about the distribution of housing characteristics in the Ukrainian population is required. This information is made public by the State Statistic Service (Ukrstat, 2020). However, this information is only available for the total population and does not differentiate between income groups. Lower income households are more likely to be equipped with less advanced technologies, thus it should be noted that the presented estimations only reflect approximations.

As the payment under the social norm depends on the number of persons living in a household, the average household sise (2.58) is retrieved from the State Statistic Service of Ukraine. Further, heat consumption is defined per square meter, thus information on the amount of heat consumed per square meter are required. The average weighted consumption for an apartment building is 156 kWh/sqm per year and for an individual house 240 kWh/sqm per year. As 51% of Ukraine's population are living in an individual house (or as part of an individual house) and 49% in an apartment building, the overall weighted average consumption is 198 kWh/sqm per year.

Based on the distribution of household characteristics, the average social norm consumption for a household is 134 kWh of electricity, 9 m^3 of gas and 1'ooo kWh of heat per month. These are multiplied with the respective fuel prices. Further, the cost for water supply, waste and building management are taken into account. In total, in 2019 the payment for housing and utilities based on social norm amounted to EUR 61 per month per household.

A share of these costs has to be carried by households. This share depends on the household income and the legally determined subsistence level. Information on both is retrieved from the State Statistics Service. To calculate the HUS when a carbon tax is phased in, potential commodity price changes are disregarded to extract the effect of the carbon tax. Table 5 presents the subsidies paid for different income groups. In the calculation, the average of the income range is used. The HUS paid per household increases by the same amount as the social norm utility bill (differences in Table 5 might result due to rounding).

Table 5: HUS for different income groups

monthly household income [EUR]	share of house-holds	HUS per household [EUR/month]								
		2022	2023	2024	2025	2026	2027	2028	2029	2030
below 170	3%	45	47	49	51	53	54	55	56	56
170 – 204	4%	41	43	45	46	47	48	49	50	50
204 - 235	7%	31	33	34	35	36	36	36	36	36
235 - 266	8%	20	21	22	23	23	22	22	20	19
266 - 299	9%	8	8	8	8	7	6	5	3	0
299 - 330	9%	0	0	0	0	0	0	0	0	0
330 - 361	9%	0	0	0	0	0	0	0	0	0
361 - 395	9%	0	0	0	0	0	0	0	0	0
395 - 426	7%	0	0	0	0	0	0	0	0	0
426 - 459	7%	0	0	0	0	0	0	0	0	0
above 459	29%	0	0	0	0	0	0	0	0	0
Social norm utility bill [EUR/month]		66	69	72	76	79	81	84	86	88
Carbon tax [EUR/tCO2]		4	9	13	17	22	26	30	35	39

Source: Own calculation

Implemented by

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy.

This project is part of the International Climate Initiative (IKI) and is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on the basis of a decision adopted by the German Bundestag. The project is implemented by BE Berlin Economics GmbH.

All results of the project are available online on www.LowCarbonUkraine.com.

We are grateful for your feedback on this Policy Proposal. Please get in touch via info@LowCarbonUkraine.com.

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