KfW Research
Focus on Economics

Green inflation? Between climate action and price stability

No. 368, 18 February 2022

Authors: Dr Jens G. Herold, phone +49 69 7431-9385, Jens_Gerrit.Herold@kfw.de
Dr Milena Schwarz, phone +49 69 7431-7578, Milena.Schwarz@kfw.de
Dr Fritzi Köhler-Geib, phone +49 69-7431-2931, Fritzi.Koehler@kfw.de
Lisa-Marie Ebner, phone +49 69 7431-2629, Lisa-Marie.Ebner@kfw.de

Germany's inflation rate has been hitting new highs of late. Energy prices in particular have risen strongly. Besides the sharp rise in demand driven by the economic recovery, supply chain problems and geopolitical tensions, causes include special effects such as the introduction of a national emissions trading System (nETS) in Germany.

This raises the question of what quantitative effects the introduction of a national carbon price in Germany has had on inflation, what else lies ahead in the years to come and what factors influence the size of the effect. This is what we will address in our Focus. Under the assumption that the costs are passed on in full by the distributors of fuels, the nETS results in hefty increases in consumer prices for fossil fuels which are directly reflected in the 2021 consumer price index with an arithmetical contribution of 0.63 percentage points (PP). The following years, however, will see only moderate contributions to inflation compared with the relevant preceding year. Relative to the base year 2020, the carbon price could result in a cumulative direct inflationary effect of approximately 1.49 PP over the next six years.

A partial analytic examination of this type, however, fails to grasp the substitution effects towards less carbon-intensive goods as well as avoidance responses – the intended goal of a rising carbon price. For the economy as a whole, the nETS results in feedback effects on consumption demand (2021: -0.9%), investment demand (-3%), gross domestic product (-0.8%) and employment (-1%). The dampening, indirect effect of decreased aggregate demand counteracts the direct effect from the increase in fossil energy prices. Taking into account these effects in our economic model, the introduction of the carbon price in Germany pushes inflation up by only a good 0.35 PP in 2021 and by just 0.15 PP over the entire period. The depth of the avoidance response in favour of less carbon-intensive goods thus determines how great an inflationary effect a rising carbon price has on the aggregate economy. The stronger the (intended) avoidance response, the lower the inflationary pressure.

Even if the causes of the current distortions in the energy markets do not primarily lie in climate action, rising prices of fossil energy sources are a key factor for a successful transition to climate neutrality because of their incentive effect. How this will impact on medium-term price stability depends on multiple factors. Policymakers can significantly contribute to making the transition to a climate neutral economy succeed in the medium and long term while maintaining a steady price level through the design of their climate policies. Key mechanisms include agreeing on a predictably rising carbon price, using public revenues from rising carbon prices to offset social hardship and ensuring the availability of sufficient fossil fuel-free alternatives to more expensive carbon-intensive energy use.

The national carbon price is leading to fossil fuel price increases …

In January 2021 Germany introduced a national emissions trading system (nETS) for the heating and transport sectors with the Fuel Emissions Trading Act (Brennstoffemissionshandelsgesetz – BEHG). It requires the distributors of fuels such as natural gas suppliers and oil companies to purchase pollution rights in the form of certificates. Carbon emissions certificates are initially issued in unlimited quantities at an annually rising fixed price. That price was set at EUR 25 per tonne of CO_2 for the year 2021. After that the price will rise gradually to EUR 55 in 2025. According to the current state of discussions, the fixed price system is to change over to a market system in 2026 with a price floor and ceiling of 55 and 65 euros respectively.[1]

If companies pass the additional costs on to households, that will have direct effects on consumer prices for heating energy and fuels. Under the assumption that the costs are passed on in full, a price of EUR 25 per tonne of CO_2 results in an arithmetical price markup of just under 6 cents per litre of fuel and heating oil and 0.5 cents per kWh for natural gas compared with the price paid for these energy sources in the year prior to the introduction of the nETS. The planned increase in fixed CO_2 prices over the years means that the price surcharges for energy sources will rise as well. In the year 2025, when the price per tonne of CO_2 is to be EUR 55, the arithmetical price markups for fuels will be around 14 cents per litre, roughly 15 cents per litre of heating oil and approximately 1 cent per kWh for natural gas. A price of EUR 65 per tonne of CO_2, which corresponds to the price ceiling set in the nETS in the year 2026, could result in price effects of roughly 16 cents per litre of fuel and 17 cents per litre of heating oil (Table 1).

Table 1: CO_2 emissions and price increase per energy component up to the year 2026

	Fixed price per tonne of CO_2 in euros	Fuels Markup in cents per litre	Heating oil Markup in cents per litre	Natural gas Markup in cents per kWh
2021	25	6.1	6.6	0.5
2022	30	7.4	8.0	0.6
2023	35	8.6	9.3	0.7
2024	45	11.0	11.9	0.9
2025	55	13.5	14.6	1.1
2026	65	15.9	17.2	1.3
Memo item: CO_2 emissions (kg per litre/kWh)		2.45	2.65	0.2

Note: The assumption is that the price ceiling of EUR 65 per tonne of CO_2 provided for under the BEHG applies in 2026. Fuels are 3/4 petrol and 1/4 diesel.

Source: Federal Office of Economics and Export Control, German Federal Environment Agency, own calculations.

What price markups will apply in reality is subject to multiple uncertainty factors. Various studies have shown that it is definitely realistic for energy and transport companies to pass almost all the costs on to consumers because their demand is very inelastic, especially over the short term.[2] In this assumption, however, the direct price effects described represent an upper limit.

Although the nETS has direct effects on consumer prices only in the areas of heating energy and fuels, the national CO_2 price can also have indirect effects on the prices of consumer goods. For one thing, as the CO_2 price makes certain inputs within the value chains more expensive for producers who then pass their increased costs on to consumers in the form of price increases for ultimate goods, the prices for further groups of goods can increase. For another, rising producer prices can also indirectly lead to special effects through substitution effects.[3] These effects were not taken into account in the calculation presented above.[4]

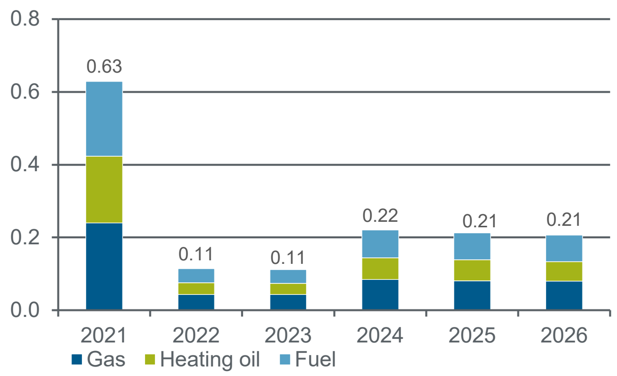
… which is driving consumer price inflation.

In the German CPI fuels and energy sources without electricity[5] are weighted at just over 7%. Arithmetically, the introduction of the nETS in the year 2021 generated a direct contribution to total CPI of 0.63 percentage points (Figure 1).[6] If we also take into account the fact that the pricing of CO_2 emissions increases the cost of inputs of goods and these increases are passed on to consumers, the inflationary effect that is directly and indirectly attributable to the introduction of the nETS could end up being significantly higher. It would then also affect core inflation without the volatile prices of energy and food. A study by the German Council of Economic Experts estimates the total inflationary effect including indirect effects at 1.16 percentage points in the year 2021.[7]

The BEHG provides for the CO_2 price to be raised continuously in the years ahead. The partial analytic effect of CO_2 pricing on the CPI inflation rate reflects this adopted price path. Compared with 2021, the year of introduction, increases will only be moderate in subsequent years. Under the assumption that after the end of the fixed price phase in the year 2025 the price per tonne of CO_2 will settle on the maximum price then applicable of presumably EUR 65, that would result in an additional contribution of 0.21 percentage points to the CPI for that year compared with the previous year. Relative to the base year 2020, the cumulative direct inflationary effect of CO_2 pricing over the period of six years would thus be approx. 1.49 percentage points.

Diagram 1: Direct contribution of national CO_2 pricing to CPI

In percentage points



Note: Calculation based on the CPI weighting pattern of the year 2015. The assumption is that the price ceiling of EUR 65 per tonne of CO_2 provided for under the BEHG applies in 2026.

Source: Destatis, own calculations

Aggregate economic impact of the nETS …

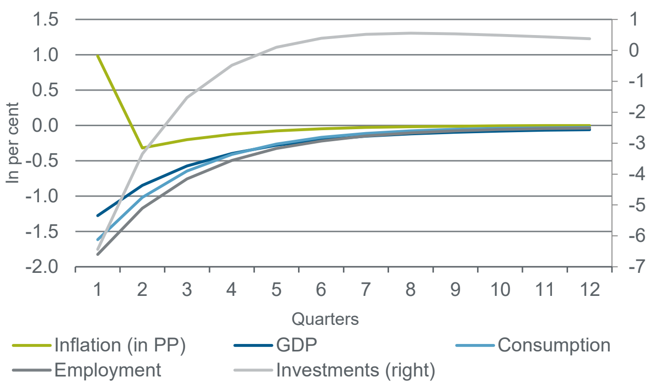
The above partial analytical observation, however, does not take into account substitution effects and avoidance responses in favour of less CO_2-intensive goods. In order to be able to make statements about the aggregate economic impact and steering effects of the nETS, for example on gross domestic product (GDP), employment or consumption demand, it is necessary to have a structural model. On the basis of the relevant literature[8] we have calibrated a medium-sized, new Keynesian structural equilibrium model in order to be able to model a typical economic cycle in Germany in response to a macroeconomic supply shock.

The observation of a price or cost shock from the energy sector can be modelled differently in this framework. More recent literature on what is referred to as Environmental DSGE Models[9] explicitly models both consumption and production of energy-intensive goods. A price increase induced by, for example, a rise in the price of crude oil or institutional changes, such as in the case of the nETS, raises the production costs of the manufacturers of energy-intensive goods. The market power of these businesses enables them to (at least partially) pass the costs on to the consumers, which leads to a decline in the consumption of such goods and – proportionately – to a drop in aggregate consumption, employment and GDP.

Avoidance responses such as reducing consumption of energy-intensive goods are not an unwanted side effect of the nETS but explicitly contribute to reaching the climate goal. However, when quantifying the aggregate effects on consumer price inflation it is necessary to take into account the dampening, indirect effect of reduced aggregate demand on inflation, which counteracts the direct effect from the increase in energy prices. As an alternative to an E-DSGE with an explicitly modelled energy good that is becoming more expensive, the nETS can also be modelled as a classic cost/supply shock on the Phillips curve. Although this modelling is somewhat less detailed, it has the advantage that it can be plotted in the framework of the 3-equation New Keynesian model which has established itself in the literature as the 'gold standard'. Here, an exogenous shock – in our case the rise in the price of fossil energy goods brought about under the nETS – increases the incremental costs of businesses which pass them on to consumers using their price setting power. This subsequently impacts on aggregated variables through inflation (or inflation expectations) (Figure 2).

Figure 2: Aggregate economic effects of the introduction of the nETS (modelled as a cost shock, +1.49 PP)

Inflation rate in percentage points. The right axis shows investment demand.



Source: Own calculations

… is contractive and slows down the price increase.

If we model the aggregate economic effects of a one-time cost shock in the amount of the arithmetical direct inflation impact of CO_2 pricing over the period of six years (1.49 PP), this will have the following impact (Figure 2): As an immediate response to the initial, unexpected price increase, consumption demand (-1.6%) and investment demand (-6.4%) dampen GDP (-1.3%), as a result of which employment also declines (-1.8%). The effect of the shock gradually weakens in the following quarters and investments actually grow again in the following years, which is to be interpreted as an adaptation response to the higher costs. Here we focus deliberately on the total effect over six years as the CO_2 price path across this period is known and can thus be perfectly anticipated.[10] This has impacts on prices through equilibrium and second-round effects. While the above partial observation still identifies an average increase in consumer prices by a total of 1.49 percentage points, the contractive equilibrium effects dampen the price increase across the economy as a whole. In the aggregate economic model the inflation rate thus rises by only a good 0.35 PP in the first year and indeed by just 0.15 PP over the entire period.

Overall, a rising CO_2 price thus has a potentially inflationary effect but this effect is significantly smaller than what can be determined on the basis of a purely partial analytic observation based on direct increases of fossil energy prices. Empirical evidence from an analysis of the introduction of national CO_2 prices in Canada and various European countries underscores this result. The politically desired increase in the cost of energy from fossil sources cooled off the economy in the cases studied.[11] In some of the cases studied, the CO_2 prices actually did not have an inflationary but a deflationary effect overall.

Based on this scenario, monetary policy must see through this effect on the inflation rate – which has been induced by the legislator but impacts on the supply side. The nature of the shock makes it virtually impossible for monetary policy to take stabilising action. In a counterfactual scenario in which monetary policy seeks to fully offset the inflationary effect from the nETS through tighter monetary policy measures, deflationary equilibrium effects on GDP growth and employment end up being even more negative.

The CO_2 price comes with distribution effects …

From an economic perspective, efficient climate action can be achieved only through the most comprehensive and uniform possible internalisation of the external costs caused by greenhouse gases (GHGs).[12] A CO_2 price ensures that CO_2 emissions are avoided at the time and location where avoidance is most cost-efficient. Making fossil energy sources more expensive creates incentives for households to change their behaviour and businesses to make their operations climate-friendly. Relative price markups are therefore explicitly desired to achieve climate goals.

Socially disadvantaged households spend a higher share of their disposable income on energy and in many cases have little influence on the choice of energy source (e.g. oil heaters in rented units). As a result, low income households carry a disproportionately high burden from rising energy and CO_2 prices relative to their household income.[13] According to calculations, the nETS could burden a household in the top income decile with roughly 0.6% of its household income annually, whereas a household in the lowest income decile would be burdened with 1.2%.[14] This unequal burden also has effects on the economy as a whole. Thus, the most recent literature[15] has studied the response of households in various income groups to a politically induced energy price shock and has demonstrated that ultimately it is only the lower income households that reduce their overall consumption to a significant and persistent degree. Furthermore, the aggregate economic downturn combined with reduced consumption demand means that these households are additionally burdened by the fact that a disproportionate share of them is employed in consumption-intensive sectors. Low income households are therefore ultimately burdened in two ways. The higher the CO_2 price rises, the heavier the burdens obviously are.

… that need to be addressed appropriately.

From a political and societal perspective, the distribution effects induced by climate policy must not be ignored. The revenues obtained from CO_2 pricing can be used to ensure a social balance. A variety of approaches is conceivable to achieve this. For example, the payment of a per capita lump sum premium or the reduction of governmental price components in the electricity price can reverse the initially regressive effect of rising energy prices into a progressive distribution effect.[16] Empirical evidence indicates that the question of how the costs of the climate transition are distributed in society could be a crucial factor for its impact on inflation.

Germany's Climate Action Programme 2030 provides for a reduction in the EEG levy from revenues obtained through the nETS. The EEG levy funds the expansion of renewable energy in the electricity market. It is a major cost component of the electricity price for households and businesses. Under the economic stimulus package of June 2020, the EEG levy for the year 2021 was set at 6.5 cents per kWh. In the previous year it was 6.76 cents per kWh. The EEG levy dropped to 3.723 cents per kWh at the beginning of 2022.[17] The coalition agreement of the new Federal Government also provides for the EEG levy to no longer be financed from the electricity price but entirely from budget funds from the year 2023. In addition, the coalition agreement provides for exploring the option of a lump-sum per capita reimbursement from the CO_2 price revenues, although there are no specific plans for this as yet.[18]

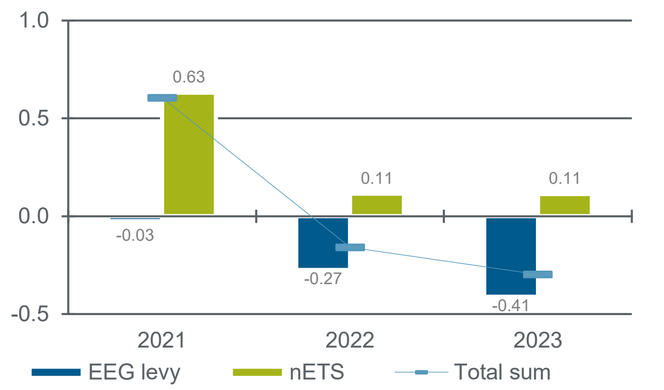
Redistributing the revenues generated from the CO_2 price through the electricity price makes economic sense. First, it creates a counterweight to the regressive effect of CO_2 pricing particularly for low income households.[19] Second, when the state-induced elements of electricity pricing are reduced, it also strengthens the incentives for businesses to focus earlier on innovative business models in the area of sector coupling.[20]

Reducing the EEG levy means two opposing forces influence inflation

Electricity is weighted at around 3% in the CPI basket of goods. The nETS does not lead to a direct electricity price markup because electricity is already priced through the European Emissions Trading System (EU ETS). If electricity producers were to pass the falling EEG levy to private households in full, that would initially have a dampening effect on consumer price inflation. But possible rebound effects on demand from the lower price would also have to be taken into account.[21]

Figure 3: Direct inflation effects of nETS compared with reduction of EEG levy

In percentage points



Note: In accordance with the most recent policy decisions, the EEG levy was 6.5 cents per kWh is in the calculation in 2021, 3.723 cents per kWh in 2022 and 0 cents per kWh from the year 2023. The assumption is that the reduction of the EEG levy in the electricity price is passed on in full to households.

Source: Destatis, own calculations

For the year 2021 the reduction of the EEG levy by 0.26 Cents per kWh (from 6.76 to 6.5 cents per kWh) compared with the previous year resulted in an arithmetical reduction of 0.93% in the electricity price and an isolated deflationary effect of -0.03 percentage points (Figure 3). A comparison of the inflationary effects of a rising CO_2 price and a falling electricity price shows that the deflationary effect of a reduction of the EEG levy in the planned amount would surpass the inflationary effect resulting from the nETS in 2022 as well as in 2023. Overall, therefore, the interplay between the two instruments means that consumer energy prices would actually fall. Relative to the base year 2020, the deflationary effect of the reduction of the EEG levy over the period of six years arithmetically amounts to approx. 0.7 percentage points. So theoretically, reducing the EEG levy can mitigate the inflationary pressure from the nETS by around half overall.

Outside this purely partial analytic observation, however, a counterweight to this effect can definitely occur across the economy as a whole. Thus, the most recent empirical evidence shows that the lowering of electricity prices, counter-financed by rising CO_2 prices, boosts economic growth and may therefore drive inflation in the short and medium term.[22]

CO_2 prices are likely to remain on a high level in Europe as well

Fossil energy sources are currently subject to two CO_2 prices in Germany: the European emissions trading system (EU ETS), which mainly prices greenhouse gases emitted by power plants, industrial plants and aviation, and the nETS for the areas of heating and transport, which are not (yet) subject to the European Emissions Trading System.[23]

In early December the ETS prices reached a new record high of just under EUR 90 per tonne of CO_2, which was nearly three times as high as in early 2021 and multiples of the level of some years ago. To be sure, part of this price increase probably also reflects growing demand resulting from the reopening of the economy. Still, there is much to suggest that the European CO_2 price will remain on a high level in the medium term. For one thing, the ETS spot prices indicate this, as they may to a certain extent reflect the expectation that the EU is now getting serious about climate action. At the same time, in its 'Fit for 55' package the EU Commission is focusing on strengthening and, with a view to the sectors covered, expanding the European Emissions Trading System in order to achieve the climate targets. Both should also be reflected in rising European CO_2 prices.

The question of how high a CO_2 price would have to be to achieve climate neutrality depends first on the sectors covered and second on the implementation and efficiency of accompanying policy measures for reducing emissions and therefore cannot be answered in general terms.[24] What should be clear, however, is that the more that ambitious climate action measures are deferred into the future, the higher the price will need to be.

As only the variation but not the level of the CO_2 price is expressed in the inflation rate, much indicates that a significant portion of the inflationary effect generated by a rising CO_2 price has already been priced in. Even if the European CO_2 price should rise to EUR 100 per tonne of CO2, that would no longer have the same effect on inflation as the increase from EUR 25 to EUR 80 per tonne – which occurred already in the year 2021. With the national price floor in the EU ETS of EUR 60 per tonne of CO_2 that was set in the coalition agreement of the new Federal Government, the European CO_2 price is not likely to fluctuate as much anymore as it did in the past and should instead stabilise at a relatively high level.

As for the national emissions trading system, what is also true is that the effects of the nETS on consumer prices were strongly felt especially in the year 2021 and made a significant contribution to the increased total inflation rate, along with other special effects. But given the politically set price path, comparable inflationary effects should no longer result from the nETS alone until the year 2026 because the inflationary effect is likely to be very minor due to the relatively moderate price increase in the coming years. However, a price jump could then indeed still be imminent. This could result from the expansion of the EU ETS to the transport and heating sectors envisaged for the year 2026 – and the ensuing probable price increase.[25] Or it could result from the political design of the market phase in the national CO_2 emissions trading system after 2026. The German Council of Economic Experts estimates that on the given price path, a price of roughly EUR 110 per tonne of CO_2 would be necessary in the nETS from the year 2027 in order to achieve the German sector targets for heating and transport in the year 2030.[26] Further studies also arrived at similar results.[27] If the price in the nETS should suddenly rise to such a level in 2027, that would naturally have even more significant direct effects on the prices of fossil energy sources and inflation than described in the preceding paragraphs.

How inflation will evolve in the course of the climate transition crucially depends on its implementation

It can be anticipated that households will seize opportunities for replacing CO_2 intensive with less CO_2 intensive goods in order to reduce their individual burden where they can. A rising CO_2 price also provides an incentive for businesses to implement measures that improve efficiency and invest in technologies that reduce or avoid emissions altogether. That will be the case particularly when the CO_2 price path is transparent – as is the case under the nETS – and thereby provides medium-term planning certainty. By establishing a reliable framework and setting a predictable, rising CO_2 price signal, economic policymakers can help steady the price level in the transition to climate neutrality.

At the same time, it has become evident that economic policy plays a role in determining how rising CO_2 prices impact on inflation overall through the ways in which it uses the revenues obtained. If in the future the Federal Government takes the revenues and disburses them to German households as a per capita premium, that is likely to have a different effect on inflation than primarily refunding the revenues levied in the form of decreasing electricity prices, as is current practice.[28] At European level, the EU Commission is planning a climate social fund as an offsetting response to rising CO_2 prices through which the member states can address national measures to mitigate social hardships resulting from rising consumer prices for fossil transport and heating fuels in their country. A broad mix of measures can therefore be expected to emerge within the EU whose effects on the European inflation rate will accordingly be difficult to calculate.

Whether businesses and households will be able to replace the more costly carbon-intensive energy uses with green and more cost-effective alternatives is what will crucially determine the effects of the climate transition on medium-term price stability. The depth of the associated avoidance responses will determine how strongly the CO_2 price will ultimately drive aggregate inflation. Looking ahead, investments in new technologies and renewable energy generation will probably lead to strong changes in the economy and reduce the high impact of fossil fuels on inflation. However, if non-fossil alternatives are not yet sufficiently available, the combination of insufficient short-term renewable energy generation capacities, weaker investment in the fossil fuel sector and rising prices of CO_2 emissions could mean that we may be facing a prolonged transition phase with rising energy prices. That would create an urgent need to adopt complementary policy measures that help make non-fossil alternatives available even in the short term. In this context, ECB Director Isabel Schnabel[29] has warned that upside risks to medium-term price stability could otherwise emerge – especially in two scenarios: first, when the prospect of persistently rising energy prices contributes to a de-anchoring of inflation expectations and second, when rising CO_2 prices and the resulting relocation of business operations bolster growth instead of dampening it.[30] If that happens she believes that monetary policy may indeed end up being forced to respond to developments.

Despite these potential risk scenarios, there is no way around a sufficiently ambitious CO_2 price level because it is the only way to ensure that emissions avoidance in future is tackled where it is most cost-efficient to do so. If adopted climate targets are instead to be achieved primarily or exclusively through regulatory measures, the resulting implicit CO_2 prices would be less transparent for the market actors but ultimately climate action would be more expensive for all – and the impact on consumer price inflation would therefore be even higher.

---

[1] The coalition agreement of the new German Federal Government sets out that the parties wish to develop a proposal on the design of the market phase after 2026. It would also be conceivable that the nETS will then be incorporated into the planned emissions trading system for transport and heating at European level (ETS 2).

[2] Fabra, N. and Reguant, M. (2014): 'Pass-through of emissions costs in electricity markets', American Economic Review, 104 (9), 2872–2899.; Hintermann, B. (2016): 'Pass-through of CO_2 emission costs to hourly electricity prices in Germany', Journal of the Association of Environmental and Resource Economists, 3 (4), 857–891.; Deltas, G. (2008): 'Retail gasoline price dynamics and local market power', The Journal of Industrial Economics, 56 (3), 613–628.; Marion, J. and Muehlegger, E. (2011): 'Fuel tax incidence and supply conditions', Journal of Public Economics, 95 (9–10), 1202–1212.

[3] Deutsche Bundesbank (2021): 'Global and European setting', Monthly Report August 2021, Frankfurt am Main, 13-29.

[4] According to calculations, the contribution to inflation of national CO_2 pricing on the CPI could roughly double as a result of indirect effects. Cf. Nöh, L., Rutkowski, F. and Schwarz, M. (2020): 'Auswirkungen einer CO_2-Bepreisung auf die Verbraucherpreisinflation' (*Effects of CO_2 pricing on consumer price inflation* – our title translation, in German), Working paper 03/2020, German Council of Economic Experts, Wiesbaden.

[5] Electricity is already part of the EU ETS. The nETS therefore does not lead to a direct electricity price markup.

[6] Fiedler, S. (2020) and Deutsche Bundesbank (2019) identified an effect on the CPI of similar magnitude. Cf.: Deutsche Bundesbank (2019), The impact of the Climate Package on economic growth and inflation, in: Monthly Report December 2019. Fiedler, S. (2020), on the consumer price effects of the Climate Package, in: Boysen-Hogrefe et al. (2020): German economy: V(irus)-shaped recession ahead. Kiel Institute Economic Outlook, No. 65 (2020|Q1). Kiel Institute for the World Economy Owing to differences in the weighting pattern the effect on the HCPI is likely to be moderately higher in each case. For methodological reasons, the effect of CO_2 pricing on the HCPI, however, is fraught with greater uncertainty. Unlike the CPI, the weighting of the HCPI is adjusted every year. Any avoidance responses in favour of less CO_2-intensive goods are therefore more likely to be reflected in the weighting pattern of the HCPI in the years after 2021. In the CPI, on the other hand, such effects should be taken into account in the weighting pattern not earlier than when the base year is switched to 2025.

[7] Nöh, L., Rutkowski, F. and Schwarz, M. (2020): 'Auswirkungen einer CO_2-Bepreisung auf die Verbraucherpreisinflation' (*Effects of CO_2 pricing on consumer price inflation* – our title translation, in German), Working paper 03/2020, German Council of Economic Experts, Wiesbaden.

[8] Hristov, N. (2016): 'The Ifo DSGE Model for the German Economy', ifo Working Paper.; Drygalla, A., Holtemöller, O. and Kiesel, K. (2020): 'The Effects of Fiscal Policy in an Estimated DSGE Model – The Case of the German Stimulus Packages During the Great Recession', Macroeconomic Dynamics, 24(6), 1315–1345.

[9] Golosov, M., Hassler, J., Krusell, P. and Tsyvinski, A. (2014): 'Optimal taxes on fossil fuel in general equilibrium', Econometrica, 82(1), 41–88.

[10] The coalition agreement of the new German Federal Government once again affirmed the CO_2 price path under the BEHG up to the year 2026.

[11] Konradt, M and Weder di Mauro, B (2021), 'Carbon Taxation and Inflation: Evidence from Canada and Europe', CEPR Discussion Paper 16396.

[12] Andersson, J. (2019), 'Carbon Taxes and CO_2 Emissions: Sweden as a Case Study', American Economic Journal: Economic Policy, Vol. 11, No 4: 1–30. Martin, R., De Preux, L. and Wagner, U. (2014), 'The impact of a carbon tax on manufacturing: Evidence from microdata', Journal of Public Economics, Vol. 117: 1–14. Känzig, D. (2021), 'The unequal economic consequences of carbon pricing', London Business School Working Paper, Social Sciences Research Network.

[13] Känzig, D. R. (2021): 'The Unequal Economic Consequences of Carbon Pricing', LBS Working Paper, Kalkuhl, M., Knopf, B. and Edenhofer, O. (2021): 'CO_2-Bepreisung: Mehr Klimaschutz mit mehr Gerechtigkeit' (*CO_2 pricing: More climate action with more justice* – our title translation, in German), MCC Working Paper, June 2021.

[14] German Council of Economic Experts (2020), Corona-Krise gemeinsam bewältigen, Resilienz und Wachstum stärken (*Overcoming the coronavirus crisis together, strengthening resilience and growth* – our title translation, in German), Annual Report 2020/21.

[15] Känzig, D. R. (2021): 'The Unequal Economic Consequences of Carbon Pricing', LBS Working Paper.

[16] Preuß, M., Reuter, W. H. and Schmidt, C. M. (2019): 'Verteilungswirkung einer CO_2-Bepreisung in Deutschland' (*Distribution effect of CO_2 pricing in Germany* – our title translation, in German), Working Paper 08/2019. German Council of Economic Experts, Wiesbaden.

[17] This decline is primarily due to the increased power exchange prices, which mechanically lead to a falling EEG levy, and not to federal subsidies from increased revenues under the nETS. The federal subsidies of EUR 3.3 billion reduce the EEG levy by the equivalent of 0.9 cents/kWh. Cf. German Federal Ministry for Economic Affairs and Energy (2021): 'EEG-Umlage 2022: Fakten & Hintergründe' (*EEG levy 2022: Facts & Backgrounds* – our title translation, in German), accessed via: https://www.bmwi.de/Redaktion/DE/Downloads/E/zahlen-und-fakten-zur-eeg-umlage-2022.pdf?__blob=publicationFile&v=4#:~:text=Die%20EEG%2DUmlage%202022%20betr%C3%A4gt,(Anstieg%20von%20103%20Prozent).

[18] The administrative feasibility in Germany will likely be a challenge for the lump sum reimbursement. Cf. i. a.: Foundation for Environmental Energy Law (2019): 'Europa- und verfassungsrechtliche Spielräume für die Rückerstattung einer CO_2-Bepreisung: Ist das Schweizer Modell auf Deutschland übertragbar?' (*Scope for the reimbursement of CO_2 pricing under European and constitutional law: is the Swiss model transferable to Germany?* – our title translation, in German), Würzburger Studien zum Umweltenergierecht No. 13, July 2019.

[19] Kalkuhl, M., Knopf, B. and Edenhofer, O. (2021): 'CO_2-Bepreisung: Mehr Klimaschutz mit mehr Gerechtigkeit' (*CO_2 pricing: More climate action with more justice* – our title translation, in German), MCC Working Paper, June 2021; German Council of Economic Experts (2020), 'Corona-Krise gemeinsam bewältigen, Resilienz und Wachstum stärken' (*Overcoming the coronavirus crisis together, strengthening resilience and growth* – our title translation, in German), Annual Report 2020/21.

[20] According to the latest scientific findings, climate neutrality can be achieved only if the growing share of electricity generated from renewables is used in transport (e.g. e-mobility) and heating (e.g. electrical heat pumps) in the future. This is referred to as sector coupling, and is being made more difficult by the current system of state-induced price components for energy sources because the fiscal burden on electricity is significantly higher than on fossil energy sources. Cf. i. a. Höfling, H. (2019). 'A successful energy transition requires a CO_2-oriented energy price reform'. Focus on Economics No. 248, KfW Research.

[21] Brockway et al. (2021): 'Energy efficiency and economy-wide rebound effects: A review of the evidence and its implications', in: Renewable and Sustainable Energy Reviews, 141. Brüggemann, A. (2021): 'The trade-offs between digitalisation and climate action: Why digitalisation must be sustainable', Focus on Economics No. 341, KfW Research.

[22] Estrada, A. and Santabárbara, D. (2019): Recycling carbon tax revenues in Spain. Environmental and economic assessment of selected green reforms.https://www.bde.es/f/webbde/SES/Secciones/Publicaciones/PublicacionesSeriadas/DocumentosTrabajo/21/Files/dt2119e.pdf, McKibbin et al. (2014): 'The economic consequences of delay in US climate policy', Climate and Energy Economics Discussion Paper.

[23] The European and the national CO_2 price both affect consumer prices in Germany. The future effects of a rising CO_2 price, however, are much easier to estimate in the framework of the fixed price system of the nETS and fraught with fewer uncertainty factors, which is why we focus on it in this analysis.

[24] The IMF estimates that a global CO_2 price of USD 75/t CO_2 would be necessary to ensure that the goals of the Paris Agreement are met. The European Commission recently simulated the CO_2 price that would be necessary to reach the new EU emissions reduction target of 55% by 2030 in the framework of various policy scenarios. In the scenario, which presupposes the expansion of the European Emissions Trading System (EU-ETS) to the building, road transport and intra-EU maritime shipping sectors, would thus require a CO_2 price of EUR 60/t CO_2 to achieve the 55% goal. For a comprehensive discussion of the required level and design of CO_2 prices for achieving various climate goals, see OECD (2018), Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading, OECD Publishing. OECD (2019), Taxing Energy Use 2019: Using Taxes for Climate Action, OECD Publishing.

[25] The empirical evidence demonstrates that the avoidance costs in the transport and building sectors are higher on average than in the industrial and energy sectors. It can therefore be assumed that the CO_2 price in the planned second emissions trading system (ETS-2) for the transport and heating sectors will be higher than in the EU ETS. Cf. i. a. Edenhofer, O., Flachsland, C., Kalkuhl, M., Knopf, B. and Pahle, M. (2019): 'Optionen für eine CO_2-Preisreform', Working Paper 04/2019 (*'Options for a CO_2 price reform'* – our title translation, in German), expert opinion for the German Council of Economic Experts, Wiesbaden.

[26] German Council of Economic Experts (2020), 'Corona-Krise gemeinsam bewältigen, Resilienz und Wachstum stärken' *(Overcoming the coronavirus crisis together, strengthening resilience and growth* – our title translation, in German), Annual Report 2020/21.

[27] Edenhofer, O., Flachsland, C:, Kalkuhl, M., Knopf, B. and Pahle, M. (2019): 'Optionen für eine CO_2-Preisreform', Working Paper 04/2019 (*'Options for a CO_2 price reform'* – our title translation, in German), expert opinion for the German Council of Economic Experts, Wiesbaden.

[28] Empirical evidence from Spain corroborates this. Cf. Estrada, A. and Santabárbara, D. (2019): 'Recycling carbon tax revenues in Spain. Environmental and economic assessment of selected green reforms'. Working Paper No. 2119, Banco de España.

[29] Schnabel, I. (2022): 'Looking through higher energy prices? Monetary policy and the green transition', Remarks by Isabel Schnabel, Member of the Executive Board of the ECB, at a panel on 'Climate and the Financial System' at the American Finance Association 2022 Virtual Annual Meeting.

[30] Cf. i. a. Metcalf and Stock (2020): 'Measuring the Macroeconomic Impact of Carbon Taxes', AEA Papers and Proceedings, Vol.110: 101-06.