Organisation for Economic Co-operation and Development

ECO/WKP(2023)28

Unclassified **English - Or. English**

22 November 2023

ECONOMICS DEPARTMENT

ECONOMIC EFFECTS OF THE EU'S 'FIT FOR 55' CLIMATE MITIGATION POLICIES: A COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

ECONOMICS DEPARTMENT WORKING PAPERS No. 1775

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All Economics Department Working Papers are available at www.oecd.org/eco/workingpapers.

JT03532378

ABSTRACT

Economic effects of the EU's 'Fit for 55' climate mitigation policies: A computable general equilibrium analysis

This study analyses the economic effects of the EU's 'Fit for 55' climate mitigation policies using the OECD ENV-Linkage model, a dynamic, global Computable General Equilibrium model. The model projects macroeconomic, sectoral, energy and emission trends for the EU, and for the five largest EU economies separately, up to 2035. Policy scenarios combine carbon pricing with regulations to reach the 'Fit For 55' emission reduction target in 2030. Additional scenarios analyse i) harmonised carbon pricing across countries and sectors, ii) different forms of revenue recycling from carbon pricing, iii) the effect of the EU's proposed Carbon Border Adjustment Mechanism on competitiveness, and iv) the effect of Russia's war against Ukraine on mitigation costs. Given the short time horizon of the analysis (until 2035), the model does not assess the positive economic benefits associated with fewer climate impacts and extreme climate events. 'Fit for 55' policies are projected to lead to a loss of GDP per capita of 2.1% in 2035 compared to the reference scenario (pre-'Fit for 55' policies), reflecting increasing production costs on the back of higher carbon pricing. Higher carbon pricing is also projected to lead to a loss of competitiveness in energy-intensive industries. The EU's proposed Carbon Border Adjustment Mechanism may only partly mitigate the loss of competitiveness of energy-intensive industries. Harmonising carbon pricing across sectors would help limit the loss to GDP per capita, as a uniform carbon price is lower and allows for directing emission reduction efforts to sectors and countries with the lowest abatement costs. Finally, Russia's war against Ukraine has not substantially increased the GDP costs of mitigation. Without the war, lower fossil fuel import prices would have led to higher fossil fuel demand, ultimately requiring more stringent mitigation action.

JEL classification codes: C68, H23; Q42; Q48; Q58; R48

Keywords: Computable General Equilibrium Model, European Union, climate change mitigation, energy

This Working Paper relates to the 2023 OECD Economic Survey of the European Union and the euro area (https://www.oecd.org/economy/euro-area-and-european-union-economic-snapshot/)

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Effets économiques des politiques d'atténuation climatique de l'UE « Fit for 55 » : une analyse d'équilibre général calculable

Cette étude analyse les effets économiques des politiques d'atténuation climatique de l'UE « Fit for 55 » à l'aide du modèle ENV-Linkage de l'OCDE, un modèle d'équilibre général calculable dynamique et global. Le modèle projette à l'horizon 2035 les tendances macroéconomiques, sectorielles, énergétiques et d'émissions pour l'UE, les cinq plus grandes économies de l'UE sont isolées. Les scénarios politiques combinent des instruments de tarification du carbone avec des réglementations sectorielles pour atteindre l'objectif de réduction des émissions « Fit For 55 » en 2030. L'étude présente plusieurs scénarios alternatifs i) la tarification du carbone harmonisée entre les pays et les secteurs, ii) les différentes formes de recyclage des revenus issus de la tarification du carbone, iii) le rôle du mécanisme d'ajustement carbone aux frontières proposé par l'UE sur la compétitivité, et iv) l'impact de la guerre de la Russie contre l'Ukraine sur les coûts des politiques de l'atténuation climatique. Compte tenu du court horizon temporel de l'analyse (jusqu'en 2035), le modèle ne tient pas compte des bénéfices économiques positifs associés à une diminution des impacts climatiques et des événements climatiques extrêmes. Les politiques « Fit for 55 » devraient entraîner une perte de PIB par habitant de 2,1 % en 2035 par rapport au scénario de référence (politiques pré-« Fit for 55 »), reflétant l'augmentation des coûts de production liée à une tarification plus élevée du carbone. Une tarification plus élevée du carbone devrait également entraîner une perte de compétitivité dans les industries à forte intensité énergétique. Le mécanisme d'ajustement carbone aux frontières proposé par l'UE n'atténuerait que partiellement la perte de compétitivité des industries à forte intensité énergétique. L'harmonisation de la tarification du carbone entre les secteurs contribuerait à limiter la perte de PIB par habitant, dans la mesure où un prix uniforme du carbone est plus bas et permet d'orienter les efforts de réduction des émissions vers les secteurs et les pays où les coûts de réduction sont les plus faibles. Enfin, les conséquences, sur le marché européens des énergies fossiles, de la guerre menée par la Russie contre l'Ukraine n'a pas sensiblement augmenté le coût des politiques de l'atténuation climatique. Sans la guerre, le prix des importations de combustibles fossiles aurait été plus faible et aurait entraîné une demande plus élevée de combustibles fossiles, nécessitant finalement des mesures d'atténuation plus strictes.

Classification JEL: C68 ; H23; Q42; Q48; Q58; R48

Mots Clés: Modèle d'équilibre Général Calculable, l'Union européenne, atténuation du changement climatique, énergie.

Ce Document de travail a trait à l'Étude économique de l'OCDE de l'Union européenne et zone euro 2023 (https://www.oecd.org/economy/euro-area-and-european-union-economic-snapshot/)

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Economic effects of the EU's 'Fit for 55' climate mitigation policies: A computable general equilibrium analysis

By Jean Chateau, Antonela Miho and Martin Borowiecki[1]

Introduction

Climate change represents one of the most pressing challenges facing the world today. Absent swift action, the repercussions of more frequent and severe climatic events will have devastating social and economic impacts (Stern, 2007[1]; IPCC, 2022[2]; Alogoskoufis et al., 2021[3]). The EU responded to the challenge in 2020 by adopting the European Green Deal, which aims at reaching net zero emissions by 2050. In 2023, the EU also adopted more ambitious climate mitigation policies to facilitate the acceleration of emissions reductions, called the 'Fit for 55' package. Notably, the legally binding targets call for at least 55% emissions reduction in 2030 compared to 1990 (European Union, 2023[4]). Achieving these emission targets requires higher carbon pricing. However, carbon pricing alone is unlikely to be enough to reach net-zero emissions. Complementary policies such as regulations are needed to encourage the substitution towards clean energy sources from fossil fuels (D'Arcangelo et al., 2022[5]; Arregui et al., 2020[6]; Böhringer et al., 2021[7]; Chen et al., 2020[8]; Howell, 2017[9]). These include stricter emission standards for vehicles or more stringent energy efficiency standards for buildings.

A wealth of literature considers the economic effect of climate mitigation policies (Borgonovi et al., 2023[10]). Carbon taxes or emissions trading systems are cost-effective instruments to decrease emissions, with a EUR 10 increase in carbon pricing associated with a 3.7% decrease in CO_2 emissions from fossil fuels in the long term (D'Arcangelo et al., 2022[11]). Other studies found emissions trading schemes to reduce emissions by an average of only between 0% and 2% per year (Green, 2021[12]). There is some evidence of negative economic effects on the productivity of smaller firms far from the productivity frontier or those facing financial constraints (Alla, 2022[13]). The majority of studies emphasise that these effects are limited, finding no negative effect of emissions trading or carbon taxes on economic growth, employment or exports (Dechezleprêtre, Nachtigall and Venmans, 2023[14]; Petrick and Wagner, 2014[15]; Metcalf and Stock, 2023[16]). Other studies also suggest that carbon pricing may spur labour reallocation from energy-intensive to energy-efficient firms, and investments in technological innovation (Parry, 2020[17]; Aghion et al., 2016[18]; Dussaux, 2020[19]). However, all these studies use data on the EU's Emission Trading System

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(ETS) for the period before the COVID-19 pandemic, when the ETS price was relatively low. Since then, the ETS price has tripled from EUR 30 per tonne of CO_2 in 2019 to EUR 90 per tonne of CO_2 in July 2023. Looking ahead, higher emission reduction targets suggest a further rise in the carbon price.

The more ambitious mitigation policies may come with potential macroeconomic costs and social repercussions. Still, these costs are necessary to avoid the potentially much higher economic costs that would arise from failure to reduce global emissions and limit climate change. Nonetheless, there is scope for the EU to raise the effectiveness of its climate mitigation policies and reduce overall economic costs. For instance, there is a unique, EU-wide carbon price for the sectors covered by the EU's ETS, notably power and energy-intensive industry. However, carbon prices vary across sectors not covered by the ETS, reducing the effectiveness of the EU's climate policy and leading to varying abatement incentives. Also, the EU's climate policy will lead to both winners and losers. For instance, countries with a larger emission footprint would see higher income losses under higher carbon pricing. This reflects a higher tax burden shouldered by firms and households in these countries. Finally, carbon pricing may lead to competitiveness losses of energy-intensive sectors. These issues raise several questions relevant for the EU's climate policy:

- What are the macroeconomic impacts of the EU's new policies to reduce net greenhouse gas emissions by at least 55% by 2030 relative to 1990 (against the reference of the previous 42.5% emission reduction target)?
- How do these macroeconomic impacts differ across countries?
- What would be the macroeconomic consequences of a uniform carbon price across all sectors?
- How can policymakers use ETS carbon price revenues most effectively to reduce the economic costs of the EU's climate change mitigation policies?
- What is the effect of the EU's proposed Carbon Border Adjustment Mechanism (CBAM) on mitigating losses to competitiveness of energy-intensive sectors?
- How do the current sanctions on EU fossil fuel imports from Russia affect the economic costs of mitigation policies?

This paper assesses the economic effects (on GDP, employment, competitiveness and carbon prices) of the EU's 'Fit for 55' climate mitigation policies using the OECD ENV-Linkages model (Chateau, Dellink and Lanzi, 2014[20]). It does not assess the economic effects from reducing GHG emissions and limiting climate change on the economy as these effects would be marginal given the short time horizon of the study (until 2035). A 'Fit for 55' scenario, where net GHG emissions are reduced by at least 55% in 2030 (compared to 1990 levels), is compared to an "EU reference scenario 2020" based on 2019 policies, i.e., a reduction of gross GHG emissions by 40% in 2030 (compared to 1990 levels), excluding emissions from the land use and forestry (LULUCF) sector. This translates into a 42.5% net emission reduction (relative to 1990), i.e., including emissions from the LULUCF sector. Another comparison is made to a hypothetical scenario without any climate policy action. The model projects macroeconomic, sectoral, energy and emission trends for the EU as a whole, and for the five largest EU economies separately (France, Germany, Italy, Poland and Spain), up to 2035. Large EU economies were selected based on the size of their population and economy. The rest of the world is grouped in twelve regions.

The policies implemented are based on the EU's 'Fit for 55' policies and national level policies, as described in National Energy and Climate Plans (Commission, 2023[21]). The 'Fit for 55' policy package includes the extension of the EU ETS system to maritime transport, a new ETS 2 on distributors of transport, industrial and residential heating fuels, the carbon border adjustment mechanism (CBAM), and more stringent minimum emission standards for vehicles, among other policies. Alternative policy scenarios analyse harmonised carbon pricing across sectors to reach the EU 'Fit for 55' emission-reduction targets, and the effect of the EU's CBAM on competitiveness of energy-intensive industries. Additional scenarios study the economic effect of different policy options for revenue recycling, including using carbon pricing revenues to lower the labour tax burden and to distribute lump sum payments to households. Non-EU countries are assumed to meet their Nationally Determined Contributions under the 2015 Paris Agreement and implement the same abatement efforts in all scenarios, corresponding to policies under the so-called "STEP scenario" of the IEA World Energy Outlook (IEA, 2021[22]). Moreover, non-EU European countries taking part in the EU-ETS — such as Iceland, Liechtenstein and Norway, and the associated countries, Switzerland and the United Kingdom — are assumed to follow the new rules of the EU-ETS under 'Fit for 55' policies, and hence assumed not to be subject to CBAM.

The 'Fit for 55' policies are projected to lead to a moderate loss in GDP per capita of 1% in 2030 compared to the reference scenario, reflecting increasing production costs on the back of higher carbon pricing. Countries currently having a larger emission intensity of production, due to specialisation in industry, as in Germany, or a higher reliance on coal power, as in Poland, are projected to see higher income losses. The effects already account for revenue recycling. In line with EU directives, the paper assumes that one-third of ETS carbon price revenues are used to finance investment in the electricity grid, with the remaining two-thirds given back to households as lump sum payments and subsidies for the take-up of electric vehicles and building renovations (Commission, 2018[23]). Higher carbon pricing is also projected to lead to a loss of competitiveness of energy-intensive industries, as measured by losses to the market share of energy-intensive commodities on world markets (compared to the reference scenario). Additional projections show that the EU's proposed CBAM may mitigate the loss of competitiveness of energy-intensive industries in the EU, but only partially. Finally, harmonising carbon pricing across sectors would reduce income losses, as a uniform carbon price is lower and allows for a more equal burden sharing across activities. Similarly, using carbon pricing revenues to lower the labour tax burden would encourage employment growth.

This study contributes to the existing literature in several ways. First, the study assesses the macroeconomic effects of the EU 'Fit For 55' climate mitigation policies, complementing existing studies on the labour market effects of the 'Fit for 55' package (Borgonovi et al., 2023[10]). Importantly, the study also incorporates the effects of Russia's war of aggression against Ukraine on fossil fuel prices and demand. Second, the study stands out for analysing the heterogeneous impact of mitigation policies on different EU countries. And finally, it accounts for bilateral trade linkages across world regions, which allows capturing the effects of mitigation policies, as well as CBAM, on the competitiveness of energy-intensive industry in the EU.

The remainder of the paper is organised as follows: Section 2 briefly introduces the model and discusses model calibration and policy scenarios. Section 3 provides the results from the model simulation. Section 4 concludes.

Data and Methodology

The OECD ENV-Linkages model

The OECD ENV-Linkages model is a global, dynamic, and sectoral Computable General Equilibrium (CGE) model that allows for simulating the effects of climate mitigation policies on emissions, macroeconomic variables, sectoral outcomes, and trade (Chateau, Dellink and Lanzi, 2014[20]). The world is divided in 18 regions, with the EU disaggregated in 6 regions (France, Germany, Poland, Italy and Spain are analysed separately, see Table **Error! No text of specified style in document.**.1 in the Annex).

The model also has a detailed sectoral and trade coverage, making it well suited to study the effects of climate policy on trade and commodity markets. For this study, the model aggregation retains 42 sectors, including 8 power technologies and 5 fossil fuel sectors[2]. The model is based on a neo-classical economic framework with perfect labour and goods markets. One important feature of the model is vintage capital. This means that new investment is allocated across sectors with the goal to equalise the return to investment across sectors. On the contrary, the existing capital stock is mostly fixed and cannot be easily reallocated across sectors without costs. Therefore, short-term elasticities of substitution across inputs in production processes (or substitution possibilities) are much lower than long-term elasticities, and so, the model is more in line with observed capital reallocation processes. Such a slow adjustment of capital increases the costs of the transition. Another model assumption is rising energy efficiency over time, even if the model does not assume major technological innovations that reduce the costs of clean energy. In the model, labour is uniform, with workers possessing one skill type. Labour reallocation from declining sectors (e.g., fossil fuel power generation) to growing sectors (e.g., renewable power generation) is assumed to be frictionless. In reality, however, inflexible labour markets and a lack of workers' skills may reduce labour reallocation across sectors, adding to the economic costs of the green transition.

Finally, the model closely matches greenhouse gas emissions to economic activities, including, among others, CO_2 emissions from fossil fuel combustion by economic agents or from production processes (cement, chemical industries, etc.), as well as all non-CO_2 GHG emissions (like N_2O emissions from fertilizer use or CH_4 emissions from livestock farming in the agricultural sector). For the sake of simplicity, this version of the model does not incorporate the feedback effects of climate change on economic variables. These effects would be marginal given the short time horizon of the study (until 2035) and the focus on emission reductions in the EU only. The economic impact of reducing air pollutants on health expenditures and labour productivity are also ignored but could be integrated in the model as done in OECD (2021[24]).

Data sources, model calibration and scenarios

In a first step, a reference scenario is calibrated to achieve similar emission reductions and energy trends as in the EU Reference Scenario 2020, against which the implications of reaching the 'Fit For 55' targets and other policy scenarios are measured (European Commission, 2021[25]). A major difference between this study's reference scenario and the EU Reference Scenario 2020 is that emissions and energy trends differ after 2020 due to COVID-19 and Russia's aggression against Ukraine. The reference scenario incorporates EU and national level policies, as described in the National Energy and Climate Plans (NECPs) and other national plans, in place or planned as of the end of 2021. As such, it represents the most comprehensive dataset possible of all EU and national policies in place before the announcement of

[2] The central input of the model is the data of the Global Trade Analysis Project (GTAP) version 10 database (Aguiar et al., 2019[36]). The database includes country-specific input-output tables for 141 countries and 65 commodities and real macro flows. It also represents world trade flows comprehensively for a given starting year. Running the model with this full disaggregation is numerically complicate so generally CGE models adopt some more restricted aggregation like the 18 regions x 42 sectors retained here.

the 'Fit for 55' policy package, and thus the most comprehensive projection of the energy system and GHG emissions for the EU and individual member countries.

The ENV-Linkages model is calibrated to the macroeconomic scenario of the OECD Long Term model. This means that projections for macroeconomic variables, including potential GDP, population (based on EUROSTAT for EU countries), employment, and investment, are fully in line with the OECD Economic Outlook 112 database (November 2023) (OECD, 2022[26]). Since some countries are not covered by the OECD Long Term model, the projections are complemented using the October 2022 IMF World Economic Projections (IMF, 2022[27]). This macroeconomic scenario includes the macroeconomic shock of Russia's war against Ukraine as well as the shutdown of imports of Russian fossil fuels by European OECD countries, which is assumed to last over the projection horizon. Energy trends for the EU are calibrated using projections of the PRIMES model provided to the European Commission and the IEA World Energy Outlook 2021 for the rest of the world (European Commission, 2021[25]; IEA, 2021[22]). GHGs emissions are calibrated using IEA CO_2 emissions from fossil fuel combustion and the JRC EDGAR database. Energy trend projections account for the macroeconomic shocks of COVID-19 and Russia's war against Ukraine.

In a second step, a 'Fit for 55' scenario is projected using information on the policies adopted as part of the EU's 'Fit for 55' policy package (European Union, 2023[4]) (Table 1). The policy package revises many aspects of the EU's climate-related legislation to achieve the new and more ambitious emission reductions target for 2030. Notably, this includes the extension of the EU ETS system to maritime transport, a stronger decrease in the annual cap on total emission permits, a faster reduction of the freely allocated carbon emission permits to some sectors, the creation of a carbon border adjustment mechanism (CBAM) for EU ETS sectors at risk of carbon leakage (i.e., energy-intensive and trade-exposed industries), a new ETS 2 on distributors of transport, industrial and residential heating fuels, more stringent minimum emission standards for vehicles, and national policies. These national policies include more ambitious reduction targets for Effort Sharing Regulation sectors, coal phase-outs in Germany, France, Italy, and Spain, and more ambitious renewable targets.

Third, a hypothetical scenario without any climate policy action is projected. In this scenario, there is neither an EU-ETS nor regulatory measures to reduce emissions in non-ETS sectors, such as transport and buildings sectors. However, energy efficiency is assumed to rise, as this is not necessarily linked to climate mitigation policies.

The model endogenously determines the price of EU-ETS emission permits to reach the 2030 emission target. This determination is based on the pathway of targeted emissions by the EU-ETS, as well as the pattern of emission permit allowances across sectors and emission sources covered by the EU-ETS. The same method is applied to determine the EU-ETS 2 emission permit price. In the EU-ETS 2, energy distributors bear the costs of the permits. For simplicity, these distributors are assumed to fully pass on the price increase to final consumers (households, transportation services, and residential heating). Finally, policies for emissions covered by the ESR sectors, such as emission standards for new vehicles or building insulation regulations, are adjusted by countries and sectors each year. Consequently, the overall target for ESR sectors is not set as for the EU-ETS. This means that the official 2030 target of a 40% emission reduction relative to 2005 can be missed if national policies in place are not sufficient to reduce emissions to meet the target.

Table 1. Main 'Fit for 55' scenario

Policy	Description
Expansion of the emission trading system (ETS)	A more ambitious emission-reduction target for ETS sectors, amounting to a 62% reduction of emissions in 2030 (compared to 2005 levels), against the previous 43% target. Up to 2025, the target is defined by an EU directive. Thereafter, the annual emission ceiling will decrease linearly to meet the 2030 target. Extension of the ETS to maritime transport sector from 2024. The ETS will apply to intra-European Economic Area (EEA) voyages and to half of the emissions on voyages from and to the EEA from outside countries. The ETS already covers power generation, energy intensive industry, and intra-European aviation. Faster decline in the annual emission cap via a steeper linear reduction factor: allowances will drop by 4.3% from 2024 to 2027; and by 4.4% from 2028 to 2030. Reduction in the emission cap by 90 million allowances in 2024; another reduction by 27 million in 2025. Phasing out of the free allocation of emission allowances to aviation by 2026. Free emission allowances will also be phased out for sectors covered by the CBAM over a nine-year period (from 2026 to 2034). In industry and transport, free ETS allowances are envisaged to be phased out from 2036.
New emission trading system for transport and residential heating fuels (ETS 2)	Creation of a new, separate ETS 2 system from 2027 for distributors that supply fuels for buildings, industrial heating processes, road transport, 42% emissions reduction target by 2030 compared to 2005. Emissions reduction trajectory set at 5.1% from 2024 and 5.38% from 2028. The carbon price is expected to be lower in the new ETS than in the traditional ETS. A potential merger of the new ETS with the traditional ETS will be reviewed in 2031.
Carbon Border Adjustment Mechanism (CBAM)	Starting in 2026, a CBAM will impose a charge on the embodied emissions of specific carbon-intensive EU imports, including aluminum, cement, electricity, fertilisers, hydrogen, iron, and steel, based on their carbon content. The importer will be charged the EU ETS price, after deducting any carbon price effectively paid in the country of origin. In the model, CBAM is based on the emission coefficient of exporter countries. This includes direct emissions of energy-intensive and trade-exposed (EITE) sectors, as well as indirect emissions associated with the carbon content of the electricity used by the EITE sectors.
More ambitious emission reduction targets for sectors covered by the Effort Sharing Regulation (ESR)	The ESR sets legally binding 2030 emissions reduction targets for each Member State, which apply to sectors not covered by emission trading. Currently, these non-ETS sectors are responsible for nearly 60% of the EU's total emissions. They include road transport, buildings, agriculture, waste management and small industry, although emission trading will be expanded to fossil fuel producers in transport and buildings in 2027. The EU-level emission reduction target for 2030 for these sectors was increased from 29% to 40% (compared to 2005 levels), through updates to national targets. However, there is no established target for emission reductions in these sectors post-2030.
More stringent CO_2 emissions standards for vehicles	From 2030 to 2034, 55% CO_2 emission reductions for new cars and 50% for new vans compared to 2021 levels. From 2035, no CO_2 emissions for both new cars and vans from 2035.
Increase share of renewables in the energy mix	By 2030, 42.5% share of renewable energy in final energy consumption, with an additional 2.5% indicative top up that would allow to reach 45%. Sector sub targets include: 49% renewable energy in buildings by 2030; 1.6% annual increase in renewables in industry; 0.8% annual increase until 2026 and 1.1% until 2030 for the heating and cooling sector.
Increased EU energy efficiency	Increase in EU-wide energy efficiency by 36% (39%) for final (primary) energy consumption in 2030, compared to 2021. This corresponds to annual cuts of 1.5% from 2024 to 2030, and 1.9% from 2030. The objective is to reduce EU final energy consumption by 11.7% in 2030. Indicative upper limit to the EU's final energy consumption of 763 Mtoe and a binding upper limit of 993 Mtoe for primary consumption.

Source: European Commission (2023[4]; 2023[21]), and authors.

A comparison of emissions reduction targets for the EU as a whole and for the five larger EU economies in the reference scenario versus the 'Fit for 55' scenario is presented in Table 2. The 'Fit for 55' policy package promises ambitious increases in emissions reduction and energy efficiency improvements. The most notable revision is the increase in the 2030 GHG emission reduction target for sectors covered by the EU ETS to 62% from a previous 43% (compared to 2005). The package also calls for a 40% emissions reduction target for non-ETS sectors in 2030 (compared to 2005), from a previous 29% reduction target. These sectors, notably road transport, buildings, agriculture, and waste, are covered under the "Effort Sharing Regulation," which is under the responsibility of EU countries given country-specific binding emissions reduction targets for 2030. Finally, the energy efficiency target and the target for renewables in the energy mix were increased: for example, the share of renewables in the energy mix increases from the current 32.5% target to 42.5%, although this is pending the approval of the revised Renewable Energy Directive.

Table 2. Emission reduction targets: reference vs. ‘Fit for 55’ scenario

		Target in 2030	
Policy	**Level**	**Reference scenario**	**‘Fit for 55’ scenario**
GHG emissions reduction, base year = 2005			
Emissions Trading System (ETS)	EU	43%*	62%*
Effort Sharing Regulation (ESR)	EU	29%	40%
Effort Sharing Regulation (ESR)	France	37%	47.5%
Effort Sharing Regulation (ESR)	Germany	38%	50%
Effort Sharing Regulation (ESR)	Italy	33%	43.7%
Effort Sharing Regulation (ESR)	Poland	7%	17.7%
Effort Sharing Regulation (ESR)	Spain	26%	37.7%
Energy use			
Renewable energy	EU	32.5% share in energy mix	42.5% share in energy mix
Energy efficiency (final energy consumption)	EU	32.5% increase vs. 2021	39% increase vs. 2021
CO_2 Vehicle Standards	EU	30% to 37.5% emission reduction vs. 2021	50% to 55% emission reduction vs. 2021

Note: * refers to GHG emissions covered by the EU-ETS. The EU-ETS does not cover all sources of actual GHG emissions, notably some methane (CH_4) sources, hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6).
Source: European Commission (2023[4]; 2023[21]).

The paper also describes some sensitivity analyses to policy scenarios and to the baseline. First, a uniform carbon price scenario is considered as an alternative. This scenario assumes an expansion of the ETS system to all sources of emissions, extending to all sectors (agriculture) and agents (households) and to all greenhouse gases, including methane. This also means that carbon prices between ETS and ETS 2 are harmonised. Such a system with a uniform carbon price would allow mitigation efforts to be directed to countries and sectors with the lowest marginal abatement cost, i.e., where the greatest technological potential to cut emissions remains.

Next, alternative policy scenarios are run to analyse the effect of the EU’s CBAM on the competitiveness of energy-intensive industries. Finally, the paper analyses the role of the war in Ukraine on the outlook for emission reductions and economic growth, by considering a counterfactual reference scenario assuming the absence of the Ukraine war and its economic consequences.

Non-EU countries are assumed to meet their Nationally Determined Contributions under the 2015 Paris Agreement and implement the same abatement efforts in all scenarios. These efforts correspond to policies under the so-called “STEP scenario” of the IEA World Energy Outlook (IEA, 2021[22]). Also, in the model, non-EU European countries taking part in the EU-ETS (Iceland, Liechtenstein and Norway) and the associated countries Switzerland, and United Kingdom, are assumed to follow the new rules of the EU-ETS under ‘Fit for 55’ policies, and not to be subject to CBAM. All main scenarios also assume that one-third of ETS carbon price revenues are used to finance investment in the electricity grid, with the remaining two-thirds given back to households (one-third for lump sum payments and one-third for subsidies for the take-up of electric vehicles and building renovations to make them more energy efficient). This key assumption follows from the European Union’s ETS Directive that auctioning revenues generated under the EU-ETS should be dedicated to climate and energy-related purposes (Commission, 2018[23]). All main scenarios also assume that all ETS revenues are distributed to Member States. Additional scenarios study the economic effect of different policy options for revenue recycling, including using carbon pricing revenues to lower the labour tax burden and to distribute lump sum payments to households.

Results

'Fit for 55' scenario

This section compares projections for the economic effects of the EU's 'Fit for 55' policies versus: 1) a scenario without any climate mitigation policy action, and 2) a scenario with mitigation policies in place before the approval of the 'Fit for 55' package in 2023.

Comparison of economic costs under 'Fit for 55' vs. the scenario without climate action

Overall, the economic costs of climate policies are projected to be higher compared to a hypothetical scenario without any climate policy action. Compared to such a scenario of no policy action, 'Fit for 55' policies are projected to lead to a loss in GDP per capita of 1.2% in 2030 (Table 3). As 'Fit for 55' policies are being implemented gradually until 2030, more pronounced economic effects are projected to materialise only after 2030, leading to a loss in GDP per capita of 2.3% in 2035 (compared to the scenario of no policy action) (Figure 1).

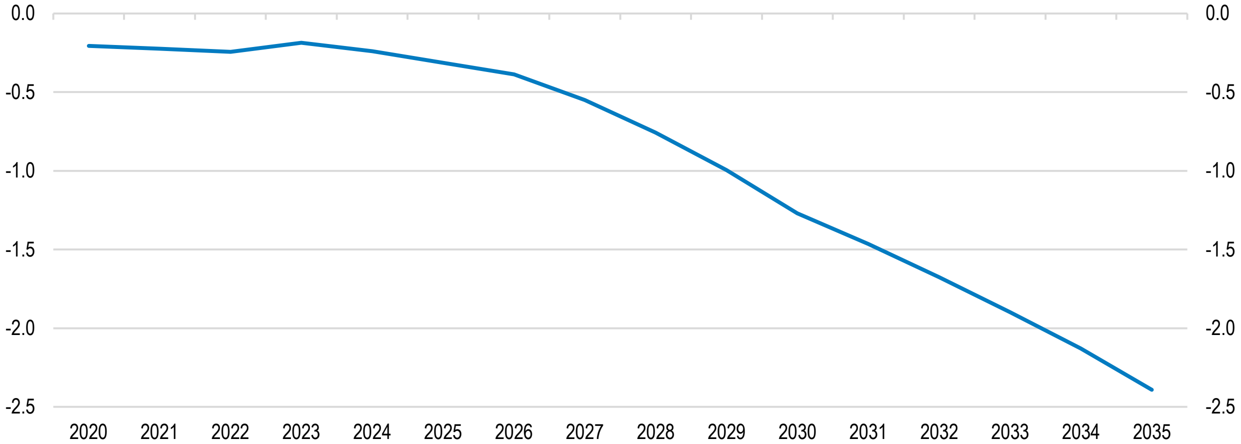
Table 3. Economic effects of the EU's 'Fit for 55' policies in 2030 versus no policy action

	No policy scenario	'Fit for 55' scenario	Percentage change compared to no policy scenario (in %)
Emissions and energy mix			
Total GHG emissions percent reduction vs 1990 (excluding LULUCF)	-34.9	-53.6	-18.7*
Total GHG emissions percent reduction vs 1990 (including LULUCF)	-37.5	-57.2	-19.7*
GHG emissions percent reduction in the ETS sectors vs 2005#	-37.4	-59.1	-21.7*
GHG emissions percent reduction in the ETS 2 sectors vs 2005	-31.6	-42.2	-10.6*
GHG emissions percent reduction in the ESR sectors vs 2005	-20.8	-37.5	-16.7*
GHG per capita	6.4	4.4	-31.4
Total final energy consumption (million tons of oil equivalent)	1030.4	955.5	-7.3
Electricity generation (terawatt hour)	3053.9	3650.7	19.5
Share of renewables in electricity generation	52.5	70.3	17.8*
Share of fossil fuels in electricity generation	29.6	10.2	-19.4*
Macroeconomic indicators			
Carbon price (EUR at 2020 prices) for EU-ETS	0.0	177.8	-
Real GDP per capita (EUR at 2014 prices)	32545.5	32157.3	-1.2
Real gross fixed investment (billion EUR at 2014 prices)	2.3	2.3	-0.5
Real private consumption (billion EUR at 2014 prices)	9.2	9.2	-0.6
Employment (million)	212.3	211.7	-0.3

Note : * denotes percentage point change. # The EU-ETS does not cover all sources of actual GHG emissions, so that the target of -62% of GHG emission reductions compared to 2005 mentioned in Table 2 translates into a smaller reduction of -59.1% for all sources of actual GHG emissions in the EU-ETS sectors. The table shows results from a scenario introducing the EU 'Fit for 55' targets, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a hypothetical no climate policy scenario, in which the EU reduces its net GHG emissions by 35% in 2030 (relative to 1990) due to improvements in energy efficiency. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

Figure 1. Economic effects of 'Fit for 55' policies increase over time

Changes in real GDP per capita, 'Fit for 55' scenario relative to no policy scenario, %



Note: The chart shows results from a scenario introducing the EU 'Fit for 55' targets, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a counterfactual scenario without climate mitigation policies.
Source: OECD ENV-Linkages model.

Comparison of economic costs between the two scenarios with climate action

Table 4 presents the results of the EU's 'Fit for 55' scenario compared to the 'reference scenario'. The EU is projected to reduce gross GHG emissions (excluding LULUCF) by 54% in 2030 (relative to 1990 levels), which is an 11 percentage-point stronger emission reduction than in the reference scenario. This translates into a reduction in net GHG emissions of 55% (including LULUCF) in 2030. This reduction stems from greater abatement in the energy sector driven by a faster rollout of renewables, and stronger energy saving efforts across all sectors, as reflected in the fall in total final energy consumption. A key assumption is that the need for conventional backup capacity for renewable generation, notably gas, will fall significantly from about 40%-50% to 7% of total electricity generation, on the back of improved energy storage and electricity transmission and distribution across the EU. In contrast, the projected reduction in total final energy consumption is insufficient to meet the EU's goal of less than 858 million tons of oil equivalent (Mtoe) by 2030. Similarly, emission reductions in sectors covered by the Effort Sharing Regulation, and under the responsibility of EU countries, are projected to remain slightly below the target (-37.5% instead of -40% target), reflecting the absence of strong policies to curb non-CO_2 emissions in agriculture.

Meeting the more ambitious emission targets will require higher carbon pricing, together with more stringent regulations. With the assumed regulatory changes, the carbon price obtained with model-simulation would need to increase almost five-fold to reduce GHG emissions by 55% in 2030 (relative to 1990 levels), compared to the previous target of 42.5% emission reductions in 2030. This translates into a carbon price of EUR 178 per CO_2 tonne in 2030, up from around EUR 30 per CO_2 tonne in the reference scenario.[3] The higher carbon price reflects that additional emission reduction efforts in sectors covered by carbon pricing will need to happen in activities with higher abatement costs once cheaper abatement options have already been exhausted. For example, OECD evidence shows that emissions from coal are more responsive to carbon pricing than emissions from all other fossil fuel categories (D'Arcangelo et al., 2022[11]). Without more stringent regulations, the carbon price would need to rise even more to achieve the

[3] The relatively low price of permits of EU-ETS in the reference scenario with respect to other studies, such as Chen et al. (2020[35]), results from a higher fossil fuel price and reduced fossil fuel demand in the EU due to sanctions on fossil fuel imports from Russia. However, it is comparable to the carbon price projected by European Commission (2021[25]), which did not consider the impact of Russia's war of aggression against Ukraine.

2030 emission reduction target. This means that reaching the more ambitious 2030 emission reduction target will also require more stringent emission standards for vehicles, improvements in energy efficiency, and reducing barriers to a faster deployment of clean energy, for instance for the issuing of permits. This needs to be complemented by national policies, such as the phasing out of coal.

Table 4. Economic effects of the EU's 'Fit for 55' policies in 2030 versus reference scenario

	Reference scenario	'Fit for 55' scenario	Percentage change compared to 'reference scenario' (in %)
Emissions and energy mix			
Total GHG emissions percent reduction vs 1990 (excluding LULUCF)	-42.4	-53.6	-11.2*
Total GHG emissions percent reduction vs 1990 (including LULUCF)	-45.4	-57.2	-11.8*
GHG emissions percent reduction in the ETS sectors vs 2005#	-44.3	-59.1	-14.8*
GHG emissions percent reduction in the ETS 2 sectors vs 2005	-33.0	-42.2	-9.2*
GHG emissions percent reduction in the ESR sectors vs 2005	-29.7	-37.5	-7.8*
GHG per capita	5.6	4.4	-21.5
Total final energy consumption (million tons of oil equivalent)	1011.6	955.5	-5.5
Electricity generation (terawatt hour)	3063.7	3650.7	19.2
Share of renewables in electricity generation	57.1	70.3	13.2*
Share of fossil fuels in electricity generation	24.3	10.2	-14.1*
Macroeconomic indicators			
Carbon price (EUR at 2020 prices) for EU-ETS	30.4	177.8	485.6
Real GDP per capita (EUR at 2014 prices)	32493.2	32157.3	-1.0
Real gross fixed investment (billion EUR at 2014 prices)	2.3	2.3	-0.5
Real private consumption (billion EUR at 2014 prices)	9.2	9.2	-0.5
Employment (million)	212.2	211.7	-0.2

Note : * denotes percentage point change. # The EU-ETS does not cover all sources of actual GHG emissions, so that the target of -62% of GHG emission reductions compared to 2005 mentioned in Table 2 translates into a smaller reduction of -59.1% for all sources of actual GHG emissions in the EU-ETS sectors. The table shows results from a scenario introducing the EU 'Fit for 55' targets, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a 'reference scenario', which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

Such an increase in the carbon price, together with stricter regulations, will also lead to economic costs in terms of real incomes and competitiveness. GDP per capita is projected to be 1% lower under 'Fit for 55' policies in 2030 than in the reference scenario, reflecting increased production costs. The loss in GDP per capita will amount to 2.1% in 2035, compared to the reference scenario, reflecting that 'Fit for 55' policies are being implemented gradually until 2030 and that higher economic effects are projected to materialise only after 2030 (see Figure **Error! No text of specified style in document.**.1 in the Annex). The relative decline in economic activity is also reflected in lower consumption as higher production costs are being passed on to consumers. Due to lower economic activity, the simulation also shows a slight decrease in investment under the 'Fit for 55' scenario, compared to the reference scenario, despite the higher investment needed to increase the share of renewables in energy production. Overall, simulations show that employment will slightly decrease, but this hides differences across sectors and countries, which are discussed below.

The projections already account for some benefits derived from using carbon pricing revenues to raise investment in the energy transition, especially in electricity grids. Without such growth-enhancing measures, the negative effect of climate policies on GDP would be higher. Projections also face potential risks, including higher-than-expected inflation, ongoing supply chain problems, and skill shortages. Another downside risk is geopolitical tensions that increase trade costs. Similarly, labour market rigidities are likely to raise the costs of labour reallocation across countries and sectors, adding to the costs of the green transition.

'Fit for 55' policies are projected to impact the sectoral composition of employment. Manufacturing will see higher employment losses compared to the 'reference scenario', reflecting the impact of higher carbon pricing on the production costs of emission-intensive industry. In contrast, the less emission-intensive service sector will see small employment losses (Table 5). Overall, 'Fit for 55' policies could reinforce the structural shift in employment away from manufacturing towards services. Regarding the power sector, the 'Fit for 55' package is projected to lead to higher employment growth relative to the reference scenario. Employment losses in fossil fuel sectors (coal and gas) are compensated by employment gains in renewable and nuclear power sectors, in line with European Commission and OECD studies (Commission, 2020[28]; Borgonovi et al., 2023[10]).

Table 5. EU employment in 2030 under 'Fit for 55' policies relative to the reference scenario, by sector

	Employment (million) under the reference scenario	Employment (million) under the 'Fit for 55' scenario	Percentage change 'Fit for 55' compared to reference scenario (in %)
Agriculture	8.3	8.3	-0.6
Manufacturing	42.8	42.5	-0.7
Services	144.2	143.9	-0.2
Power	16.9	17	0.8
Coal powered electricity	0.1	0.0	-66.7
Gas Powered electricity	0.0	0.0	-37.6
Nuclear power	0.2	0.2	24.6
Hydro power	0.1	0.1	37.4
Wind power	0.3	0.5	50.6
Solar power	0.1	0.1	37.7
Total	212.2	211.7	-0.2

Source: OECD ENV-Linkages model.

The aggregate effects discussed above conceal cross-country differences (Table 6). Emission reductions are achieved in large part due to a stronger shift to renewables in Germany and Spain. In contrast, the electricity mix remains more carbon intensive in Italy and Poland, where emission reductions are driven by improvements in energy efficiency. As in the case of the EU, three of the five largest EU economies (France, Germany, and Spain) could, according to model-simulations, miss their national emission reduction targets in Effort Sharing Regulation sectors, including agriculture, where few concrete measures are taken. In contrast, Italy and Poland achieve their emission reduction targets in Effort Sharing Regulation sectors. Furthermore, countries with a higher current emission intensity of production are projected to see higher income losses, notably Poland.

Higher carbon pricing may result in a loss of competitiveness in energy-intensive industries, as measured by reductions in their market share on world markets, and losses to their gross output (compared to the 'reference scenario'), this is in line with other CGE studies (Carbone and Rivers (2017[29]) and (Chateau, Jaumotte and Schwerhoff, 2023[30]). Overall, export market shares and the gross output of energy-intensive industries would decline in all large EU economies and the EU, despite the implementation of CBAM (see below). Impacts on competitiveness should, however, be heterogenous across countries and sectors (see below).

Table 6. Economic effects of the EU's 'Fit for 55' policies in 2030, by country

Percentage changes compared to the reference scenario (in %)

	EU	DEU	ESP	FRA	ITA	POL
Emissions and energy mix						
Total GHG emissions reduction vs 1990 (excluding LULUCF)	-11.2*	-10.5*	-14.2*	-4.9*	-10.0*	-21.5*
Total GHG emissions reduction vs 1990 (including LULUCF)	-11.7*	-10.3*	-16.3*	-5.2*	-10.1*	-22.8*
GHG emissions reduction in the ETS sectors	-14.8*	-17.3*	-9.5*	-5.9*	-7.8*	-32.0*
GHG emissions reduction in the ETS 2 sectors	-9.2*	-10.1*	-9.7*	-5.4*	-5.9*	-22.1*
GHG emissions reduction in the ESR sectors	-7.7*	-8.2*	-7.7*	-4.3*	-10.1*	-12.2*
GHG per capita	-21.5	-26.6	-19.9	-9.4	-18.4	-33.3
Total final energy consumption	-5.5	-5.6	-8.0	-2.0	-5.0	-11.0
Electricity generation	19.2	29.9	7.9	17.4	16.1	31.8
Share of renewables in electricity generation	70.3	87.2	87.4	44.2	73.9	73.0
Share of fossil fuels in electricity generation	10.2	12.8	3.5	2.3	26.1	27.0
Share of renewables in electricity generation, percentage point change relative to the reference scenario	13.2*	24.9*	4.9*	1.1*	19.9*	43.2*
Share of fossil fuels in electricity generation, percentage point change relative to the reference scenario	-14.1*	-24.9*	-5.3*	-2.5*	-19.9*	-43.2*
Macroeconomic indicators						
Real GDP per capita	-1.0	-1.1	-1.1	-0.6	-1.0	-3.0
Real gross fixed investment	-0.5	-0.5	-0.5	-0.3	-0.6	-0.8
Real private consumption	-0.5	-0.6	-0.3	-0.3	-0.6	-1.8
Employment	-0.2	-0.2	-0.2	-0.1	-0.2	-0.8
Market share of energy-intensive industries**	-1.0*	-0.2*	-0.1*	-0.1*	-0.0*	-0.1*
Real gross output of energy-intensive industries**	-3.9	-2.6	-4.9	-2.3	-2.6	-8.7

Note: * denotes percentage point change. ** Energy-intensive industries are iron and steel, chemicals, pulp and paper, non-metallic minerals and non-ferrous metals. The table shows results from a scenario introducing the EU 'Fit for 55' targets, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a reference scenario, which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

Uniform carbon pricing

Table 7 shows the results of a hypothetical 'Fit for 55' scenario with uniform carbon pricing relative to the 'Fit for 55' scenario (for results by country, see Table **Error! No text of specified style in document.**.2 in the Annex). A uniform carbon price for all sectors and activities allows the EU to reach the same emission reduction as in the 'Fit for 55' scenario but at a lower carbon price of EUR 105 in 2030, versus a carbon price of EUR 178 in the 'Fit for 55' scenario. GDP per capita is projected to be 0.3% higher than in the 'Fit for 55' scenario (Figure 2).

The lower effect of a uniform carbon price on GDP per capita reflects several factors. First, carbon pricing is extended to all sectors, including agriculture. This means that methane and nitrous oxide emissions in agriculture will be directly priced, among other greenhouse gases. This, in turn, is projected to lead to higher methane and nitrous oxide emission reductions compared to the reference scenario (Figure 3, Panel A). Second, the carbon price is equalised across the ETS, the ETS 2, and the ESR sectors. This means that there is a unique carbon price for all sectors and activities, directing emission-reduction efforts to activities with lowest abatement costs. The result is a more cost-efficient allocation of emission-reduction efforts across country and sectors (Panel B and C). For instance, compared to the 'Fit for 55' scenario, emission-reduction efforts are more concentrated in activities with low abatement costs in ETS 2 and ESR sectors, including agriculture, transport and buildings. In contrast, the ETS sectors contribute less to emission reductions under uniform carbon pricing, reflecting that low abatement cost opportunities have already been exhausted in these sectors. Likewise, abatement efforts are more concentrated in Italy and Spain relative to the 'Fit for 55' scenario. This also reflects lower abatement costs, including renewable power generation.

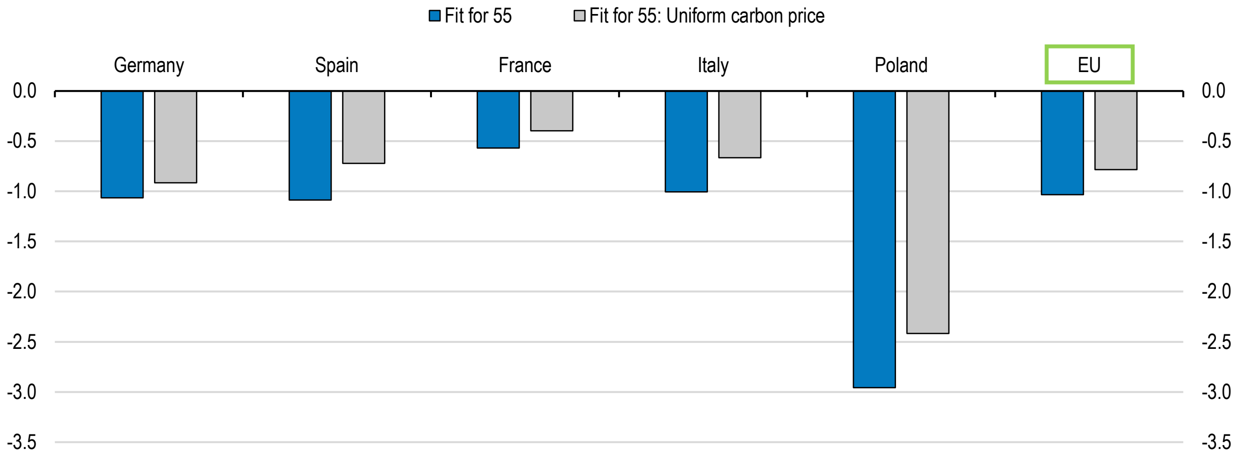
Table 7. Economic effects of uniform carbon pricing in 2030

	'Fit for 55' scenario	'Fit for 55' scenario with uniform carbon pricing	Percentage change compared to 'Fit for 55' scenario without uniform carbon pricing (in %)
Emissions and energy mix			
Total GHG emissions percent reduction vs 1990 (excluding LULUCF)	-53.6	-53.6	0*
GHG emissions percent reduction in the ETS sectors vs 2005	-59.1	-57.9	1.3*
GHG emissions percent reduction in the ETS 2 sectors vs 2005	-42.2	-40.7	1.5*
GHG emissions percent reduction in the ESR sectors vs 2005	-37.5	-39.0	-1.5*
Share of renewables in electricity generation	70.3	64.8	-5.5*
Share of fossil fuels in electricity generation	10.2	16.0	5.8*
Macroeconomic indicators			
Carbon price (EUR at 2020 prices) for EU-ETS	177.8	104.6	-32.8
Real GDP per capita (EUR at 2014 prices)	32157.3	32238.6	0.3
Real gross fixed investment (billion EUR at 2014 prices)	2.3	2.3	0.4
Real private consumption (billion EUR at 2014 prices)	9.2	9.2	0.2
Employment (million)	211.7	211.6	0.0

Note: * denotes percentage point change. The table shows results from a scenario introducing the EU 'Fit for 55' targets with uniform carbon pricing across sectors and countries, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a reference scenario, which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

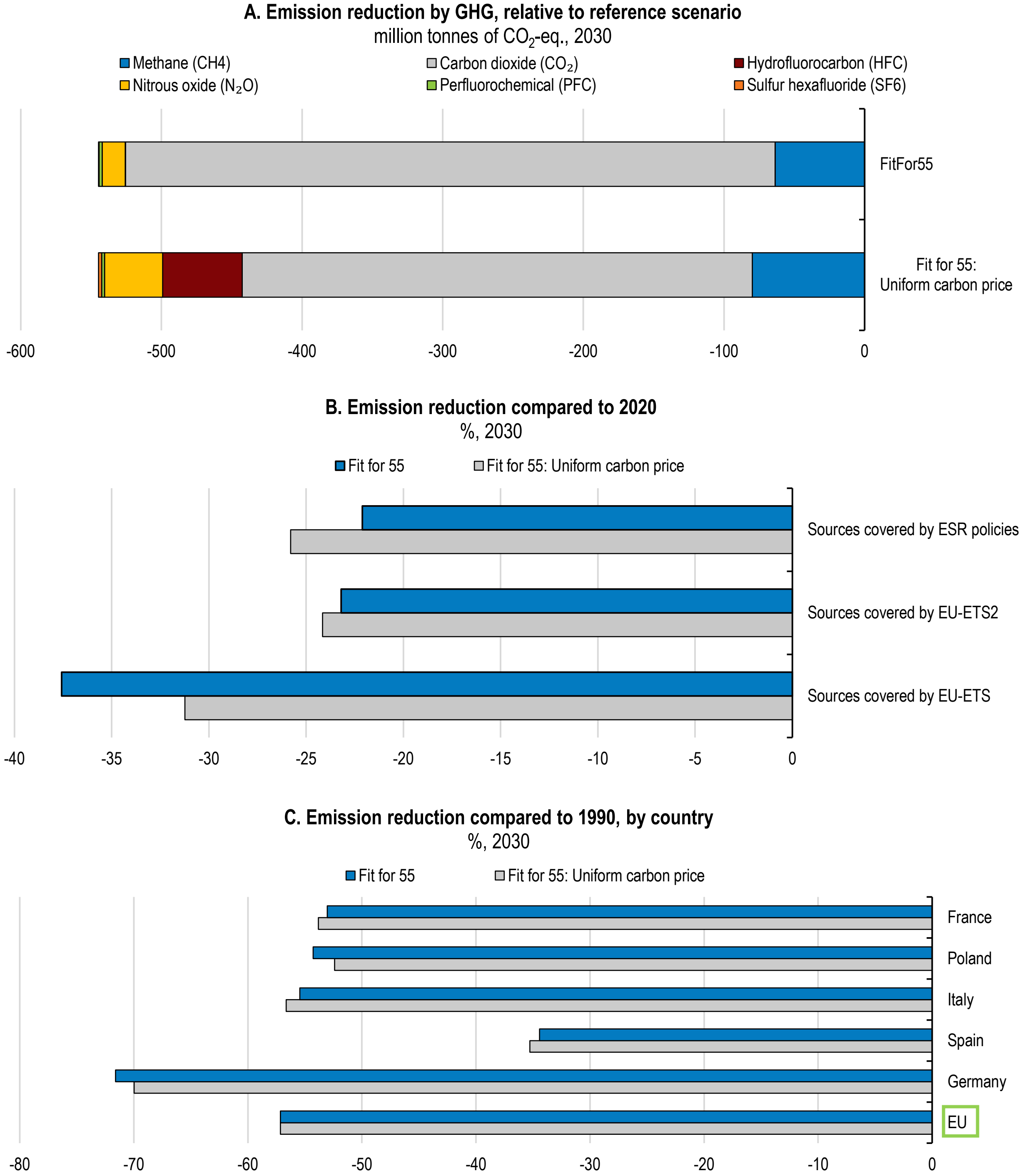
Figure 2. Uniform carbon pricing can lower the economic costs of mitigation policies

Changes in real GDP per capita in 2030, 'Fit for 55' scenario relative to 'reference scenario', %



Note: The figure shows results from a scenario introducing the EU 'Fit for 55' targets, with and without uniform carbon price across sectors and countries. In both scenarios the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a 'reference scenario', which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario.
Source: OECD ENV-Linkages model.

Figure 3. Uniform carbon pricing encourages a more efficient allocation of abatement activities



Note: The figure shows results from a scenario introducing the EU 'Fit for 55' targets, with and without uniform carbon price across sectors and countries. In both scenarios the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a 'reference scenario', which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the 'reference scenario'.
Source: OECD ENV-Linkages model.

The Carbon Border Adjustment Mechanism

An additional projection considers the impact of the 'Fit for 55' policies excluding the Carbon Border Adjustment Mechanism (CBAM), all else being equal. This means that the price of carbon permits in the EU-ETS is adjusted so that emission reductions remain the same with and without CBAM. Starting in 2026, the CBAM will impose a charge on the emissions embodied in specific carbon-intensive EU imports, including aluminium, cement, fertiliser, iron, and steel, based on their carbon content. Similar to an environmental tariff, the EU importer of a commodity produced outside the EU will be charged the EU ETS price on the carbon content of imported products, deducting any carbon price effectively paid in the country of origin. The interest of this scenario is to analyse the sectoral-country impacts. Specifically, it considers the impact of the Carbon Border Adjustment Mechanism on the competitiveness of energy-intensive and trade-exposed industries (EITE) on world markets, in addition to the primary goal of CBAM to mitigate the competitiveness loss on the internal market.[4] To do so, the difference between the 'Fit for 55' scenario with and without CBAM is considered.

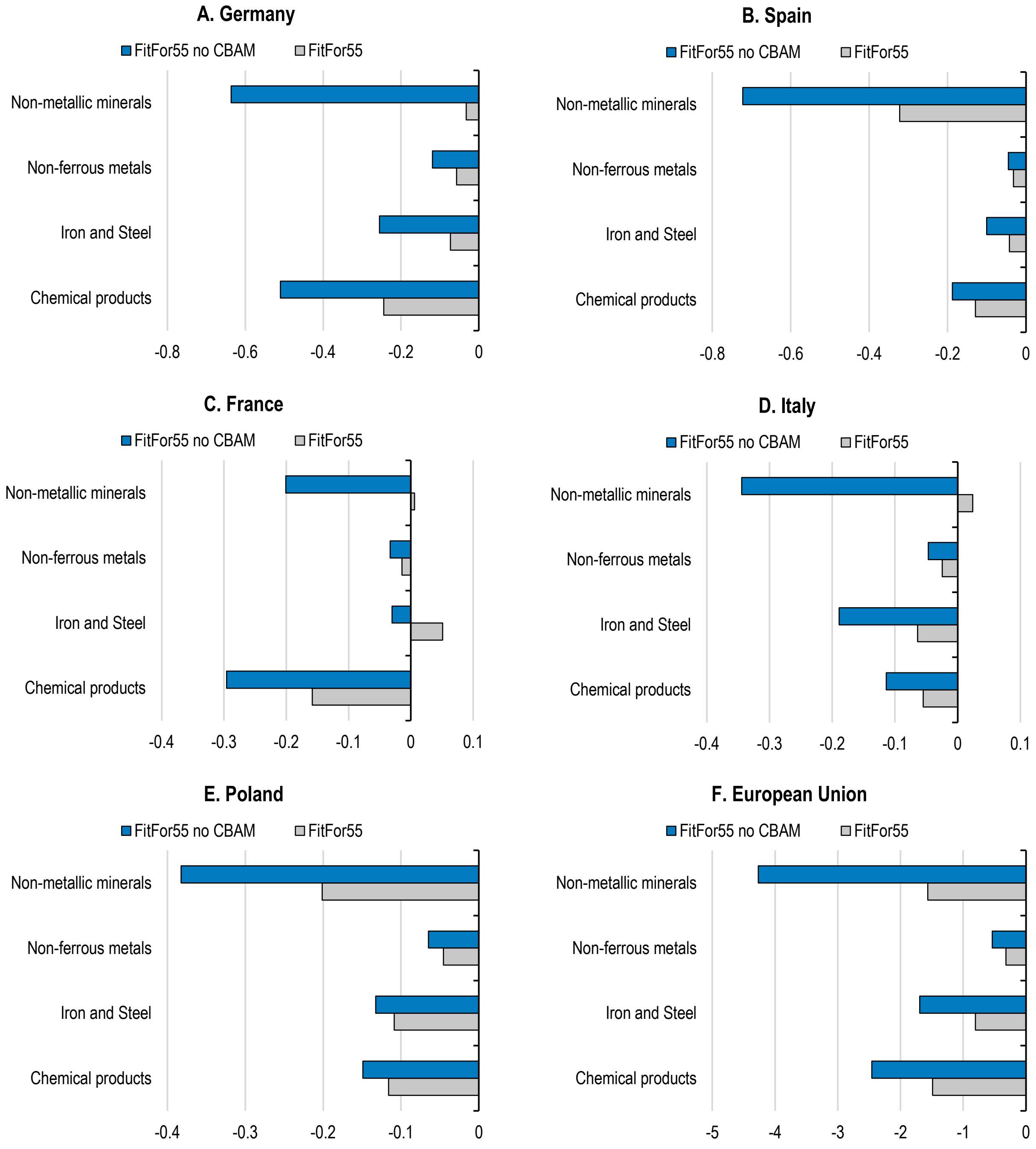
Importantly, CBAM may not fully mitigate the losses in competitiveness, when compared to the reference scenario, in line with Böhringer, Balistreri and Rutherford (2012[31]) (Table **Error! No text of specified style in document.**.3 in the Annex). Similarly, a meta-analysis by Branger and Quirion (2014[32]) suggests that carbon border adjustment mechanisms can offset competitive losses but not fully. Nonetheless, the magnitude by which CBAM can soften the loss is heterogenous across sectors and countries (Figure 4). For instance, CBAM is shown to be more effective in reducing competitiveness losses for more carbon-intensive sectors, such as non-metallic minerals (mostly cement) and, to a lesser extent, iron and steel. Results for chemical products and non-ferrous metals (e.g., copper and aluminium) are more modest. The effects may reflect that non-metallic minerals, primarily cement, exhibit limited extra-EU trade, making them potentially better guarded by CBAM. On the other hand, non-ferrous metals, like copper and aluminium, with a higher extra-EU trade share might be less protected.

Moreover, in the 'Fit for 55' scenario with CBAM, Poland and Spain bear the brunt of the market share loss. This may reflect that these countries have a relatively high share of extra-EU exports in CBAM sectors (Commission, 2021[33]). In contrast, France and Italy stand out, as they have some sectors which gain in competitiveness under the 'Fit for 55' policy scenario with CBAM, when compared to the reference scenario. However, this gain comes at the expense of some of their EU partners. Overall, gross output of EITE declines in all EU economies even if these losses are more than halved in magnitude by the CBAM mechanism (Table **Error! No text of specified style in document.**.4 in the Annex).

[4] In this analysis, the EITE industries include iron and steel, chemicals, non-metallic minerals non-ferrous metals and pulp and paper. Notice that "pulp and paper" is traditionally in this composite sector, but are not subject to CBAM in the paper, following EU directive.

Figure 4. The Carbon Border Adjustment Mechanism may only partly reduce losses to competitiveness

EITE market share, percentage point difference with respect to reference scenario, 2030



Note: The figure shows results from a scenario introducing the EU ‘Fit for 55’ targets, with and without the Carbon Border Adjustment Mechanism. In both scenarios, the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a reference scenario, which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario. The market share of a country for a given commodity is defined as its share of exports in world total exports. To read the chart, in Panel A, the difference to the reference scenario of -0.25 and -0.5 percentage point, respectively for the ‘Fit for 55’ scenario and the ‘Fit for 55 scenario with no CBAM’, for Germany’s market share in chemicals means that the share of German exports in world total exports for chemicals drops from 6.2% in the ‘reference scenario’ to 5.9% in the ‘Fit for 55’ scenario and to 5.65% in the ‘Fit for 55 scenario with no CBAM’.
Source: OECD ENV-Linkages Model.

Economic effects of different uses of carbon pricing revenues

So far, all scenarios assumed that revenues from carbon pricing are used to finance investment in electricity grids (one-third of revenues), subsidies for the take-up of electric cars and home insulation (one-third of revenues), and lump-sum payments to households (one-third of revenues). An additional revenue recycling scenario assumes that governments balance their budgets each year by adjusting the wage income tax rate. This means that revenues from higher carbon prices are used entirely to lower the wage income tax rate. Such a lowering of labour taxes increases labour supply by making employment more attractive. As a result of the policy, employment and household consumption growth is projected to be higher than in the 'Fit for 55' scenario, while maintaining the same loss to GDP per capita as in the 'Fit for 55' scenario (Table 8).

Table 8. Economic effects of using carbon pricing revenues to lower the labour tax burden

	'Fit for 55' scenario	'Fit for 55' scenario with all revenues used to lower the labour tax burden	Percentage change compared to 'Fit for 55' scenario (in %)
Real GDP per capita (EUR at 2014 prices)	32157	32152	0.0
Real household consumption per capita (EUR at 2014 prices)	20411	20423	0.1
Employment (million)	211.7	212.5	0.4

Note: The 'Fit for 55' scenario assumes that one third of revenues from carbon pricing are used to finance investment in electricity grids, with the remaining two thirds used to finance subsidies for the take-up of electric cars and home insulations, and lump sum payments to households.
Source: OECD ENV-Linkages model.

Another option is to distribute carbon pricing revenues as lump-sum transfers, i.e., all revenues from higher carbon pricing are used to provide payments to households. The effect of lump-sum payments on GDP is lower as they only affect income and do not alter labour supply directly in the model. Hence, the loss in GDP per capita is 0.2% higher than in the 'Fit for 55' scenario, which projects a loss to GDP per capita of 1% in 2030 (compared to the reference scenario) (Table 9).

Table 9. Economic effects of using carbon pricing revenues for lump-sum payments to households

	'Fit for 55' scenario	'Fit for 55' scenario with all revenues used for lump-sum payments to households	Percentage change compared to 'Fit for 55' scenario (in %)
Real GDP per capita (EUR at 2014 prices)	32157	32082	-0.2
Real household consumption per capita (EUR at 2014 prices)	20411	20362	-0.2
Employment (million)	211.7	211.5	-0.1

Note: The 'Fit for 55' scenario assumes that one-third of revenues from carbon pricing are used to finance investment in electricity grids, with the remaining two-thirds used to finance subsidies for the take-up of electric cars and home insulations, and lump-sum payments to households.
Source: OECD ENV-Linkages model.

Russia's war against Ukraine

Lastly, a counterfactual world is considered where there is no Russian war against Ukraine, and so, the EU continues trading fossil fuels with Russia with the same intensity as before the war.[5] This means that in the 'counterfactual reference' scenario and the 'counterfactual Fit for 55' scenario, fossil fuels for EU countries would be cheaper and more abundant. Such a counterfactual analysis allows to assess some consequences of the war in Ukraine on GDP and emission reductions. In this counterfactual reference scenario, the EU's GDP per capita in 2030 would be about 0.6% higher relative to the reference scenario with war, given access to cheaper Russian fossil fuels (Table 10 and Table **Error! No text of specified style in document.**.5 in the Annex). However, it comes at the cost of a lower reduction of GHG emissions due to higher demand for fossil fuels, as they are cheaper than in the scenario with war. The higher demand for cheap fossil fuels also implies a higher cost of mitigation under the counterfactual 'Fit for 55' scenario without Russia's war of aggression against Ukraine. Relative to the 'counterfactual reference scenario', we see a loss in GDP per capita of 1.2%, compared to a loss in GDP per capita of 1% under the 'Fit for 55' scenario (with war against Ukraine). This cost is also reflected in the higher carbon price necessary to reach the same 'Fit for 55' policy targets, from 178 EUR in the 'Fit for 55' scenario with the war to 243 EUR in the same scenario without the war.

Table 10. Russia's war against Ukraine lowered demand for fossil fuels, implying lower mitigation costs in 2030

	Counterfactual reference scenario - no Russian war - percentage change compared to reference scenario with war (in %)	Counterfactual 'Fit for 55' scenario - no Russian war - percentage change compared to counterfactual reference scenario – no war (in %)
Emissions and energy mix		
Total GHG emissions reduction vs 1990 (excluding LULUCF)	1.4*	-11.8*
Total GHG emissions reduction vs 1990 (including LULUCF)	1.5*	-12.3*
Share of renewables in electricity generation	-2.2*	15.1*
Share of fossil fuels in electricity generation	2.9*	-16.5*
Macroeconomic effects		
Carbon price (EUR at 2020 prices) for EU-ETS	122.1	260.3
Real GDP per capita (EUR at 2014 prices)	0.6	-1.2

Note: * denotes percentage point change. The table shows results from a counterfactual reference scenario and a counterfactual 'Fit for 55' scenario without Russia's war against Ukraine. Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

Summary and conclusions

This study analyses the economic effects of the EU's 'Fit for 55' climate change mitigation policies for the EU and five large EU economies using a dynamic global Computable General Equilibrium model. The EU is projected to reduce gross GHG emissions by 54% in 2030 (relative to 1990) under 'Fit for 55' policies. Emission reductions are mainly driven by sectors covered by emission trading. This reflects greater abatement in the energy sector, driven by a faster rollout of renewables, together with improvements to energy efficiency. A key assumption is that the need for conventional backup capacity for renewable generation, notably gas, will fall significantly from about 40%-50% to 7% of total electricity generation

[5] The recent changes in trade patterns of fossil fuel between EU and other western Europeans countries, as well as increasing gas imports from Norway and USA, have been modelled with increasing iceberg costs. In the counterfactual scenario, these assumptions on iceberg costs are relaxed, keeping costs at 2020 levels.

capacity, given improved energy storage and energy trade across the EU. In contrast, emission reductions in sectors covered by the Effort Sharing Regulation, and under the responsibility of EU countries, remain below target, due to few concrete measures to reduce agricultural emissions, among other factors.

To achieve the emission reduction of 54% in 2030 (relative to 1990), the carbon price would need to increase roughly five-fold compared to the reference scenario (with a previous target of 42.5% emission reductions in 2030), in addition to other mitigation polices. This translates into a carbon price of EUR 178 per CO_2 tonne in 2030. Such an increase in the carbon price, together with more stringent regulations, will also lead to economic costs. GDP per capita is projected to be 1% lower under 'Fit for 55' policies than in the reference scenario. Projections show stronger economic effects of 'Fit for 55' policies to materialise only after 2030, leading to a loss of GDP per capita of 2.1% in 2035 compared to the reference scenario. Still, these costs are necessary to avoid the potentially much higher economic costs from failure to reduce global emissions and to limit climate change. Countries with a current larger emission intensity of production are projected to see higher income losses, notably Poland. The GDP effects already consider benefits from using carbon pricing revenues to raise investment in electricity grids and buildings' insulation, among other green-investment policies. Higher carbon pricing is also projected to lead to a loss of competitiveness of energy-intensive industries (compared to the reference scenario). The EU's proposed Carbon Border Adjustment Mechanism may only partly mitigate the loss of competitiveness of energy-intensive industries. Reducing GHG emissions would also lead to economic benefits by reducing the cost of addressing climate extremes. However, these benefits are beyond the scope of the paper.

Employment is projected to slightly decrease compared to the reference scenario, but this hides differences across sectors. Manufacturing is expected to see higher employment losses compared to the reference scenario, reflecting the impact of higher carbon pricing on emission-intensive industry. In contrast, less emission-intensive service sectors are expected to witness only a modest decline in employment. As regards the power sector, employment losses in fossil fuel sectors are projected to be compensated by employment gains in renewable energy sectors.

Harmonising carbon pricing across sectors would help limit the decline in GDP per capita to 0.8% in 2030 compared to the reference scenario. A uniform carbon price for all sectors would allow the EU to reach the same emission reduction as in the 'Fit for 55' scenario, but at a lower carbon price of EUR 105 in 2030. The lower effect of a uniform carbon price on GDP per capita stems from the broader emission coverage of carbon pricing, including in agriculture, although there are political and practical challenges associated with an expansion of carbon pricing (OECD, 2021[34]). Also, a uniform carbon price would direct emission reduction efforts to sectors and countries with the lowest abatement costs. Similarly, using carbon pricing revenues to lower the labour tax burden would encourage employment growth.

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Annex 1.A. Additional tables and results

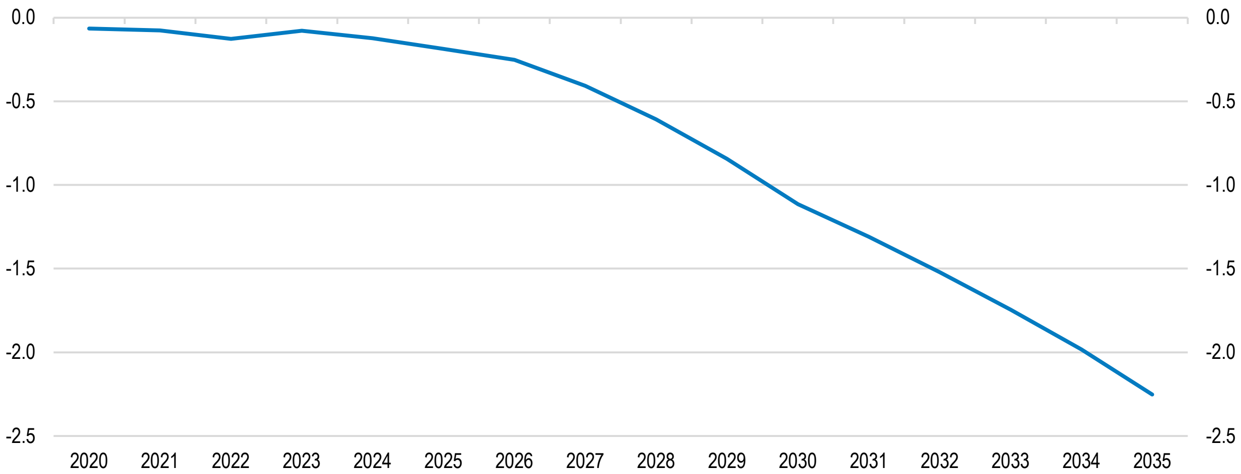
Table Error! No text of specified style in document..1. The ENV-Linkage model aggregation retained in this study

Regions	
DEU	Germany
ESP	Spain
FRA	France
ITA	Italy
POL	Poland
REU	Rest of EU countries
CHN	China
IND	India
OAF	Africa
ODA	Other developing and emerging East Asia
OEA	Other developing and emerging Eurasia (OEURASIA)
OEL	OECD Latin America (Mexico, Costa Rica, Chile, Colombia) plus Canada
OEP	OECD Pacific (Japan, South Kora, Australia, New Zealand)
OEU	OECD Europe non-EU countries (UK, Norway, Iceland, Turkey, Switzerland and Israel)
OLA	Other developing and emerging Latin America
OME	Middle east countries
RUS	Russian Federation
USA	United States of America
Sectors	
1. omn-a	Minerals n.e.s.
2. lum-a	Wood products
3. ppp-a	Paper and paper products
4. nmm-a	Non-metallic minerals
5. fmp-a	Fabricated metal products
6. mvh-a	Motor vehicles
7. otn-a	Other transport equipment
8. ele-a	Electronics
9. ome-a	Machinery and equipment n.e.s.
10. eeq-a	Electrical equipment
11. bph-a	Basic pharmaceuticals
12. rpp-a	Rubber and plastic products
13. omf-a	Other manufacturing (includes recycling)
14. i_s-a	Iron and steel
15. nfm-a	Non-ferrous metals
16. frs-a	Forestry
17. fsh-a	Fisheries
18. coa-a	Coal extraction
19. oil-a	Crude oil extraction
20. gas-a	Natural gas extraction plus manufacture and distribution
21. p_c-a	Petroleum and coal products
22. cns-a	Construction
23. osg-a	Other collective services
24. wtp-a	Water transport
25. atp-a	Air transport
26. otp-a	Transport n.e.s.: Land transport and transport via pipelines
27. crp-a	Chemical products

28. lvs-a	Livestock
29. cro-a	All crops
30. osc-a	Other business services
31. wts-a	Water supply; sewerage; waste management and remediation activities
32. fdp-a	Food products
33. txt-a	Textiles
34. clp-a	Coal powered electricity
35. olp-a	Oil powered electricity
36. gsp-a	Gas powered electricity
37. nuc-a	Nuclear power
38. hyd-a	Hydro power
39. wnd-a	Wind power
40. sol-a	Solar power
41. xel-a	Other power
42. etd-a	Electricity transmission and distribution

Figure Error! No text of specified style in document.**.1. Economic effects of 'Fit for 55' policies increase over time**

Changes in real GDP per capita, 'Fit for 55' scenario relative to reference scenario, %



Note: The chart shows results from a scenario introducing the EU 'Fit for 55' targets, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a reference scenario, which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990).
Source: OECD ENV-Linkages model.

Table Error! No text of specified style in document..2. Economic effects of uniform carbon pricing in 2030, by country

Percentage changes compared to the reference scenario (in %)

	EU	DEU	ESP	FRA	ITA	POL
Emissions and energy mix						
Total GHG emissions reduction vs 1990 (excluding LULUCF)	-11.2*	-8.8*	-15.0*	-6.3*	-11.2*	-19.8*
Total GHG emissions reduction vs 1990 (including LULUCF)	-11.7*	-8.7*	-17.1*	-6.6*	-11.3*	-21.0*
GHG emissions reduction in the ETS sectors	-13.6*	-13.8*	-8.4*	-9.5*	-8.9*	-26.0*
GHG emissions reduction in the ETS 2 sectors	-7.7*	-8.5*	-7.8*	-3.9*	-4.7*	-19.8*
GHG emissions reduction in the ESR sectors	-9.3*	-7.9*	-10.4*	-4.5*	-11.2*	-17.1*
GHG per capita	-21.5	-22.4	-20.9	-12.1	-20.6	-30.6
Total final energy consumption	-6.2	-6.6	-7.3	-3.5	-5.3	-11.5
Electricity generation	3.7	6.6	0.0	3.5	3.0	5.6
Share of renewables in electricity generation	64.8	77.9	85.4	43.7	64.0	54.7
Share of fossil fuels in electricity generation	16.0	22.1	5.7	3.4	36.0	45.3
Share of renewables in electricity generation, percentage point change relative to the reference scenario	7.6*	15.5*	2.8*	0.7*	10.0*	24.8*
Share of fossil fuels in electricity generation, percentage point change relative to the reference scenario	-8.3*	-15.5*	-3.1*	-1.3*	-10.0*	-24.8*
Macroeconomic indicators						
Real GDP per capita	-0.8	-0.9	-0.7	-0.4	-0.7	-2.4
Real gross fixed investment	-0.1	-0.1	0.0	-0.1	-0.1	-0.5
Real private consumption	-0.3	-0.6	-0.2	-0.2	-0.4	-0.8
Employment	-0.3	-0.3	-0.2	-0.1	-0.2	-0.7

Note: * denotes percentage point change. The table shows results from a scenario introducing the EU 'Fit for 55' targets with uniform carbon price across sectors, which means that the EU reduces net GHG emissions by 55% in 2030 (relative to 1990). Results are shown relative to a reference scenario, which is based on 2019 policies, meaning that the EU reduces its net GHG emissions by at least 42.5% in 2030 (relative to 1990). Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model.

Table Error! No text of specified style in document..3. Economic effects of the EU's 'Fit for 55' policies without CBAM in 2030

	Fit for 55 - no CBAM scenario	Percentage change compared to reference scenario (in %)	Percentage change compared to 'Fit for 55' with CBAM (in %)
Emissions and energy mix			
Total GHG emissions reduction vs 1990 (excluding LULUCF)	-53.6	-11.2	0.0*
Total GHG emissions reduction vs 1990 (including LULUCF)	-57.1	-11.7	0.0*
GHG emissions reduction in the ETS sectors	-59.1	-14.8	0.0*
GHG emissions reduction in the ETS 2 sectors	-42.2	-9.2	0.0*
GHG emissions reduction in the ESR sectors	-37.4	-7.7	0.0*
GHG per capita	4.4	-21.5	0.0
Total final energy consumption (million tons of oil equivalent)	952.4	-5.9	-0.3
Electricity generation (terawatt hour)	3633.1	18.6	-0.5
Share of renewables in electricity generation	70.1	12.9*	-0.2*
Share of fossil fuels in electricity generation	10.4	-13.9*	0.2*
Macroeconomic effects			
Carbon price (EUR at 2020 prices) for EU-ETS	172.7	468.8	-2.9
Real GDP per capita (EUR at 2014 prices)	32156.7	-1.0	0.0
Real gross fixed investment (billion EUR at 2014 prices)	2.3	-0.5	0.0
Real private consumption (billion EUR at 2014 prices)	9.2	-0.5	0.0
Employment (million)	211.7	-0.2	0.0
Market share of energy-intensive industries, %**	23.8	-1.8*	-0.8*
Real gross output of energy-intensive industries**	2004	-5.9	-2.1

Note: * denotes percentage point change. ** Energy-intensive industries are iron and steel, chemicals, pulp and paper, non-metallic minerals and non-ferrous metals. The table shows results from a scenario introducing the EU 'Fit for 55' targets without the Carbon Border Adjustment Mechanism. Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source OECD ENV-Linkages model.

Table Error! No text of specified style in document..4. Economic effects of the EU's 'Fit for 55' policies without CBAM in 2030, by country

Percentage changes compared to the reference scenario (in %)

	EU	DEU	ESP	FRA	ITA	POL
Emissions and energy mix						
Total GHG emissions reduction vs 1990 (excluding LULUCF)	-11.2*	-10.5*	-14.3*	-5.0*	-10.0*	-21.3*
Total GHG emissions reduction vs 1990 (including LULUCF)	-11.7*	-10.2*	-16.4*	-5.2*	-10.0*	-22.6*
GHG emissions reduction in the ETS sectors	-14.8*	-17.3*	-9.7*	-6.0*	-7.7*	-31.6*
GHG emissions reduction in the ETS 2 sectors	-9.2*	-10.1*	-9.7*	-5.4*	-5.9*	-22.1*
GHG emissions reduction in the ESR sectors	-7.7*	-8.1*	-7.7*	-4.3*	-10.1*	-12.1*
GHG per capita	-21.5	-26.5	-20.0	-9.4	-18.4	-33.0
Total final energy consumption	-5.9	-6.0	-8.2	-2.2	-5.2	-11.1
Electricity generation	18.6	28.9	7.7	17.1	15.5	30.6
Share of renewables in electricity generation	70.1	86.9	87.3	44.2	73.5	72.2
Share of fossil fuels in electricity generation	10.4	13.1	3.6	2.3	26.5	27.8
Share of renewables in electricity generation, percentage point change relative to the reference scenario	12.9*	24.5*	4.8*	1.1*	19.5*	42.4*
Share of fossil fuels in electricity generation, percentage point change relative to the reference scenario	-13.9*	-24.5*	-5.2*	-2.5*	-19.5	-42.4*
Macroeconomic indicators						
Real GDP per capita	-1.0	-1.1	-1.1	-0.6	-1.0	-2.9
Real gross fixed investment	-0.5	-0.6	-0.5	-0.3	-0.6	-0.8
Real private consumption	-0.5	-0.6	-0.3	-0.3	-0.6	-1.8
Employment	-0.2	-0.2	-0.2	-0.1	-0.2	-0.8
Market share of energy-intensive industries, %**	-1.8*	-0.4*	-0.2*	-0.2*	-0.1*	-0.1*
Real gross output of energy-intensive industries**	-3.1	-3.3	-3.7	-1.5	-2.6	-5.4

Note: * denotes percentage point change. ** Energy-intensive industries are iron and steel, chemicals, pulp and paper, non-metallic minerals and non-ferrous metals. The table shows results from a scenario introducing the EU 'Fit for 55' targets without the Carbon Border Adjustment Mechanism. Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages model

Table Error! No text of specified style in document..5. Effects of the EU's 'Fit for 55' policies in a scenario without war in Ukraine in 2030, by country

Percentage changes compared to the counterfactual reference scenario without Russia's war against Ukraine (in %)

	EU	DEU	ESP	FRA	ITA	POL
Emissions and energy mix						
Total GHG emissions reduction (excluding LULUCF)	-11.8*	-9.9*	-14.0*	-5.3*	-14.0*	-18.2*
Total GHG emissions reduction (including LULUCF)	-12.3*	-9.6*	-16.0*	-5.6*	-14.1*	-19.3*
GHG emissions reduction in the ETS sectors	-14.9*	-14.5*	-9.7*	-5.8*	-13.5*	-25.2*
GHG emissions reduction in the ETS 2 sectors	-13.2*	-12.9*	-10.8*	-6.6*	-15.1*	-24.9*
GHG emissions reduction in the ESR sectors	-8.9*	-10.1*	-7.0*	-5.0*	-11.3*	-13.4*
GHG per capita	-21.9	-26.3	-20.3	-10.2	-20.9	-30.1
Total final energy consumption	-8.1	-7.1	-9.3	-2.9	-11.5	-11.4
Electricity generation	19.8	32.2	8.2	17.8	8.7	41.1
Share of renewables in electricity generation	70.0	90.8	88.1	44.4	60.7	79.1
Share of fossil fuels in electricity generation	10.7	9.2	2.7	1.8	39.3	20.9
Share of renewables in electricity generation, percentage point change relative to the reference scenario	15.1*	20.9*	4.5*	1.1*	31.2*	38.3*
Share of fossil fuels in electricity generation, percentage point change relative to the reference scenario	-16.5*	-20.9*	-4.9*	-2.4*	-31.2*	-38.3*
Macroeconomic indicators						
Real GDP per capita	-1.2	-1.3	-1.3	-0.7	-1.1	-3.2
Real gross fixed investment	-0.5	-0.6	-0.5	-0.3	-0.6	-0.9
Real private consumption	-0.7	-0.8	-0.5	-0.4	-1.2	-2.0
Employment	-0.3	-0.3	-0.3	-0.1	-0.3	-0.8

Note: * denotes percentage point change. The table shows results from a counterfactual reference scenario and a counterfactual 'Fit for 55' scenario without Russia's war against Ukraine. Non-EU countries are assumed to reduce emissions as in the reference scenario. The shares of renewables and fossil fuels in electricity generation do not add up to 100 percent, with nuclear energy accounting for the difference.
Source: OECD ENV-Linkages Model.