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**Research Report**

## EU competitiveness and the 2030 framework: A industry perspective. Final report referring to EASME/COSME/2014/031

ZEW-Gutachten und Forschungsberichte

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# **EU competitiveness and the 2030 framework – An industry perspective**

Final Report

Referring to

EASME/COSME/2014/031

Written by Claire Gavard and Sebastian Voigt  
*November – 2017*

**ZEW**

Zentrum für Europäische  
Wirtschaftsforschung GmbH  
Centre for European  
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# **EU competitiveness and the 2030 framework – An industry perspective**

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## Executive Summary

With the EU 2020 climate and energy package and the 2030 framework, the European Union has set clear objectives to be on track to reduce its greenhouse gas emissions by 80% compared to 1990 levels by 2050.

The objective of this work is to conduct a comparable analysis that takes account of EU climate energy and policy developments and recent Commission's proposals, including its 'Clean Energy for All Europeans' package (EC, 2016a) and its proposals for an Effort Sharing Regulation for the period 2021-2030 (EC, 2016d) and revised EU Emissions Trading System (EU ETS) (EC, 2015b), as well as international climate negotiations orientated towards the preparation of climate pledges for 2030 in the context of the Paris Agreement.

The analysis is conducted with the PACE (Policy Analysis based on Computable Equilibrium) model. Four main policy scenarios are considered to examine the impact of the 2030 targets on the competitiveness of the EU's industrial sectors. They reflect two levels of action within the Paris Agreement (EU unilateral action vs. international action beyond 2020) and two ways of using the EU ETS auction revenues (lump-sum transfer to households vs. subsidies for Renewable Energy Sources (RES)).

In addition, these four scenarios are also examined with some variants to analyse further the impact of different settings for RES support schemes in Member States (MS). Indeed, the model was developed<sup>1</sup> to allow for different types of RES support, which can also be combined: RES public support paid by tax payers, electricity levy directed to RES support and paid by electricity users and RES subsidy financed by the auction revenues. In the four main scenarios, the RES support settings have been chosen to be as

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<sup>1</sup> The model was already including public support (paid by tax papers) to electricity generation from renewable energy. We developed it to allow support RES via an electricity levy. We introduced the possibility for MS to exempt some of their industrial sectors from this levy or to use the ETS auctions revenues to reduce this levy.



close as possible to the current situation in the different MS while in variant (1) RES support is assumed to be an electricity levy in all MS. In variant (2), RES support is also a levy everywhere in Europe but the ETS sectors are not exempted from the levy.<sup>2</sup>

The main scenarios and their properties are given in Table 1. Their variants are presented in Table 2.

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<sup>2</sup> ETS sectors are exempted in the main scenarios and in variant (1).

**Table 1: Main scenarios and their properties**

	Baseline	Scenario int	Scenario uni	Scenario int_ren	Scenario uni_ren
<b>EU GHG reduction targets</b>	2020: -20% vs. 1990 2030: -27.6% vs. 1990	2020: Same as baseline 2030: -40% vs. 1990			
<b>CO<sub>2</sub> reduction targets in non-EU regions</b>	No targets	NDC <sup>3</sup> objectives until 2030	NDC objectives until 2020; No emission constraints afterwards	NDC objectives until 2030	NDC objectives until 2020; No emission constraints afterwards
<b>EU renewable targets</b>	2020: 20% renewable share in gross final energy consumption	2020: Same as baseline 2030: 27% share of renewable energy in gross final energy consumption, target translated into 45% of renewable energy in the electricity sector;			
<b>Permit allocation in EU ETS</b>	Free allocation to sectors on carbon leakage list at all times; cross sectoral correction factor included; auctioning in other cases*	Free allocation up to sector specific benchmark in leakage sectors; auctioning in other cases*			
<b>Permit allocation in non-EU countries</b>	No permits	Full auctioning in all sectors			
<b>Auctions revenues recycling</b>	Lump-sum transfer to households	Lump-sum transfer to households		Revenues are used to subsidize renewable energy production	

\* Full auctioning in the power sector.

<sup>3</sup> Nationally Determined Contributions

**Table 2:** Variants of the main scenarios

	Baseline	Main scenarios (int, uni, int_ren, uni_ren)	Variants 1 (int_1, uni_1, int_ren_1, uni_ren_1)	Variants 2 (int_2, uni_2, int_ren_2, uni_ren_2)
<b>Support for electricity generation from Renewable Energy Sources in Europe</b>	No support	Electricity levy* in Germany, France, Italy, Spain and the Rest of Eastern Europe  Public support** in the UK and Poland  50% electricity levy* and 50% public support** in the Rest of Western Europe	Electricity levy in all EU regions	Electricity levy in all EU regions
<b>Electricity levy* exemption rules in Europe (where applicable)</b>	Not applicable	All ETS sectors are exempted in EU regions where a levy applies	All ETS sectors are exempted	No sector is exempted

\* Paid by electricity consumers (including households and all economic sectors).

\*\* Paid by tax payers.

Table 3 shows macroeconomic and environmental indicators for the four policy scenarios and their main variants for the EU28 aggregate in 2030. Table 4 and Table 5 respectively present EU output change for selected sectors and EU world market shares in 2030. More detailed results are available in Appendix, including all scenarios and variants, economic sectors and EU regions/Member States modelled.

**Table 3:** Selected macroeconomic and environmental indicators for policy scenarios – EU28 aggregate in 2030 <sup>4</sup>

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	int_ren_1	int_2	int_ren_2
CO2 emissions (Gt)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Including ETS emissions (Gt)	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	75.3	74.0	75.1
CO2 price non-ETS (2010 €)	180	159	173	153	187	176	182	174
Free allowance share (%)	26.6	26.0	26.6	26.0	26.6	26.6	26.6	26.6
Change in consumption (trillion 2010 €)	0.011	-0.027	0.011	-0.028	0.013	0.012	0.012	0.012
GDP (% change vs. baseline)	-0.7	-0.9	-0.6	-0.9	-0.7	-0.6	-0.7	-0.6
CO2 emissions (% change vs. baseline)	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9
Including ETS emissions (Gt)	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6
Energy demand (% change vs. baseline)	-6.5	-8.2	-6.1	-7.9	-7.0	-6.3	-7.0	-6.4
Electricity demand (% change vs. baseline)	3.1	2.0	4.4	3.1	1.7	3.7	1.3	3.5
Primary energy consumption (% change vs. baseline)	-4.7	-7.0	-4.3	-6.8	-5.5	-4.6	-5.7	-4.7
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.1	-0.3	0.1	-0.3	0.1	0.1	0.1	0.1

A first observation is that the effect of international action compared to unilateral action is larger than the effect of the analysed auctions revenues

<sup>4</sup> We present the results for selected scenarios. Results for all sectors are in appendix.

recycling option: the impact of the level of international climate action on the European carbon price, the GDP, the consumption level or EU primary energy consumption is significantly larger than the effect of changing the way auctions revenues are used. This gives an insight of the relative importance of the two main aspects of climate policy examined in this study.

**Table 4:** Selected results of changes in sectoral output (% change vs. baseline) – EU28 aggregate in 2030

<b>Sectoral output (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	int_ren_1	int_2	int_ren_2
Refined oil and coal products	2.5	-1.1	2.6	-1.2	2.1	2.4	1.7	2.2
Paper, pulp and printing	0.0	-0.2	-0.1	-0.2	0.0	-0.1	-0.4	-0.2
Fertilizers	0.9	-2.0	1.1	-1.9	0.8	1.0	0.7	1.0
Organic chemicals	2.8	-1.5	2.9	-1.4	2.8	2.8	2.4	2.7
Inorganic chemicals	1.0	-1.3	1.1	-1.2	0.9	1.0	0.7	0.9
Other chemicals, rubber, plastic	0.3	-3.9	0.7	-3.5	-0.1	0.5	0.2	0.7
Cement	0.2	-0.7	0.1	-0.8	0.2	0.1	-0.2	0.0
Bricks, tiles, construction products	0.4	-1.2	0.3	-1.3	0.4	0.3	-0.1	0.1
Glass	-0.3	-2.2	-0.4	-2.3	-0.2	-0.3	-0.8	-0.6
Ceramics	-1.4	-2.3	-1.5	-2.3	-1.4	-1.5	-1.9	-1.8
Other non-metallic minerals	-5.2	-5.9	-4.9	-5.7	-5.6	-5.0	-5.4	-5.0
Iron and steel - manufacturing	-1.5	-2.3	-1.7	-2.5	-1.4	-1.6	-2.7	-2.3
Iron and steel - further processing	-3.7	-6.2	-4.0	-6.5	-3.6	-3.9	-5.2	-4.7
Aluminium	-0.5	-1.5	-0.8	-1.8	-0.5	-0.8	-3.2	-2.3
Other non-ferrous metals	-1.3	-2.2	-1.5	-2.3	-1.2	-1.5	-3.2	-2.5
Electricity	1.1	-0.1	2.3	0.9	-0.5	1.5	-0.7	1.4
Air transport	1.1	-4.0	1.0	-4.1	1.2	1.1	1.0	1.0
Crude oil	-1.5	-0.7	-1.4	-0.6	-1.6	-1.5	-1.6	-1.5
Transport equipment	-2.4	-0.1	-2.3	-0.1	-2.4	-2.4	-2.3	-2.3
Machinery and equipment	-1.6	-0.1	-1.6	-0.1	-1.6	-1.6	-1.6	-1.6
Inland transport	-2.9	-3.9	-2.7	-3.7	-3.1	-2.8	-3.0	-2.8
Food and beverages	-1.3	-1.1	-1.2	-1.1	-1.3	-1.2	-1.2	-1.2

A second observation is that, when there are losses in sectoral output, these are most of the time not associated with losses in competitiveness, even in

the case of unilateral EU climate action.<sup>5</sup> This is due to the fact that the change in the world market share also depends on the economic outputs in the rest of the world. Macroeconomic and sectoral impacts for different aggregate world regions can be found in Tables 38 to 41 of Appendix 8.3 for the two main scenarios *int* and *uni*.

Third, as can be expected, we observe that ETS sectors always benefit from being exempted from the electricity levy compared to when they are not (higher sectoral output).

In the case of international action, more ambitious global climate policies result in lower fossil fuel and electricity prices. This benefits all ETS sectors: their output as well as their world market shares increase.<sup>6</sup> The EU ETS carbon price rises as a consequence of a larger demand for fossil fuel and electricity from the covered sectors. Among non-ETS sectors, those that are relatively more energy intensive<sup>7</sup>, such as Inland transport, similarly benefit from the reduced energy prices. On the contrary, the other sectors are disadvantaged by the lower global demand (-0.67% in the global GDP in *int* compared to the baseline scenario, -0.25% in *uni*) due to the more stringent climate constraint. Their output is reduced. In terms of competitiveness, most EU sectors gain world market shares due to the reduced carbon constraint differential between the EU and the rest of the world. Only *Transport equipment* or *Machinery and equipment*<sup>8</sup> lose competitiveness.

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<sup>5</sup> For example, for *Other non-metallic minerals*, losses in output range between 4.9 and 6.2% across all scenarios and variants – see Appendix – but losses in world market shares are always below 0.1 percentage point.

<sup>6</sup> The electricity sector loses some world market shares, due to higher electricity production in the rest of the world.

<sup>7</sup> Energy intensity measured as toe/M€ of production

<sup>8</sup> For manufacturing sectors, we suggest two effects take place. On the one hand, the tighter climate constraint in non-EU regions should result in increased world market shares for the EU industry. On the other hand, given the labor cost differences between the EU and developing regions, the energy cost share in total costs of most sectors is relatively larger in developing regions than in the EU. For manufacturing sectors, which use more labor, the

The non-ETS carbon price used to represent the emissions constraint in the non-ETS sectors rises by 13% in case of international climate action compared to unilateral action. This is mostly driven by an increased activity of the EU transport sector<sup>9</sup> and the associated oil demand. In aggregate for the EU, the GDP impact of international action is positive (in relative terms) compared to unilateral action: -0.7% in *int* compared to -0.9% in *uni*. The positive impact of reduced energy prices on ETS sectors and other relatively energy intensive sectors seems to compensate the negative impact of a reduced global demand on the rest of the economy.

Regarding the effect of using ETS auction revenues to support electricity generation from renewable sources, we observe a rise in electricity demand in the whole economy (3.1% change in *int* compared to the baseline scenario, 4.4% in *int\_ren*) due to the reduced electricity levy that households and some sectors have to pay to support renewable energy in the power sector. This causes the ETS price to increase in the scenarios with the renewable subsidy: 1.3% increase in the *int\_ren* compared to *int*, 0.8% increase in *uni\_ren* compared to *uni*. For the ETS sectors other than electricity, the impact depends on the exemption rules. If they have to pay the electricity levy (variant (2) of the scenarios), they are better off when auction revenues are used to subsidize power generation from RES. They then use more electricity. Due to an income effect, their demand for fossil fuel also increases. If the ETS sectors are exempted (main scenarios and variant (1)), the use of auctions revenues to subsidize renewable electricity generation make them worse off. In terms of competitiveness, this auction revenue recycling option seems to have no significant impact on the world market shares of the EU ETS sectors, except for electricity, which is obviously better off when benefiting from the subsidy.

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benefit from reduced global energy prices is relatively higher in developing regions than in the EU.

<sup>9</sup> The increased activity in the transport sector is due to a demand effect from the sectors that benefit from international action.

**Table 5: Selected sectoral shares in global market and changes in percentage points compared to baseline – EU28 aggregate in 2030**

<b>World market share</b>	int		uni		int_ren		uni_ren		int_1		int_ren_1		int_2		int_ren_2	
Refined oil and coal products	19.9	0.6	19.3	-0.1	19.9	0.6	19.3	-0.1	19.8	0.5	19.9	0.5	19.8	0.5	19.9	0.5
Paper, pulp and printing	23.8	0.1	23.7	-0.1	23.8	0.1	23.7	-0.1	23.8	0.1	23.8	0.1	23.8	0.1	23.8	0.1
Fertilizers	11.3	0.1	11.0	-0.2	11.3	0.2	11.0	-0.2	11.3	0.1	11.3	0.2	11.3	0.1	11.3	0.2
Organic chemicals	14.3	0.4	13.8	-0.2	14.4	0.4	13.8	-0.2	14.3	0.4	14.4	0.4	14.3	0.3	14.3	0.4
Inorganic chemicals	14.4	0.1	14.2	-0.2	14.5	0.1	14.2	-0.1	14.4	0.1	14.5	0.1	14.4	0.1	14.5	0.1
Other chemicals, rubber, plastic	17.8	0.2	17.1	-0.5	17.9	0.3	17.2	-0.4	17.8	0.2	17.9	0.3	17.8	0.2	17.9	0.3
Cement	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0
Bricks, tiles, construction products	16.2	0.1	16.1	-0.1	16.2	0.1	16.1	-0.1	16.2	0.1	16.2	0.1	16.2	0.0	16.2	0.0
Glass	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.6	0.1	13.6	0.1	13.6	0.1
Ceramics	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0
Other non-metallic minerals	10.5	-0.1	10.4	-0.1	10.5	0.0	10.4	-0.1	10.5	-0.1	10.5	0.0	10.5	-0.1	10.5	-0.1
Iron and steel - manufacturing	7.6	0.0	7.5	-0.1	7.6	-0.1	7.5	-0.1	7.6	0.0	7.6	-0.1	7.5	-0.1	7.5	-0.1
Iron and steel - further processing	12.1	-0.2	11.8	-0.5	12.1	-0.2	11.8	-0.5	12.1	-0.2	12.1	-0.2	12.0	-0.3	12.0	-0.3
Aluminium	9.3	0.0	9.2	-0.1	9.3	0.0	9.1	-0.1	9.3	0.0	9.3	0.0	9.1	-0.2	9.2	-0.1
Other non-ferrous metals	10.0	-0.1	9.9	-0.2	10.0	-0.1	9.9	-0.2	10.0	0.0	10.0	-0.1	9.9	-0.2	9.9	-0.1
Electricity	16.5	-0.6	17.8	0.6	17.0	-0.1	18.3	1.2	16.2	-0.9	16.8	-0.3	16.1	-1.0	16.8	-0.3
Air transport	22.9	0.2	22.3	-0.4	22.9	0.2	22.3	-0.5	23.0	0.2	22.9	0.2	22.9	0.2	22.9	0.2
Crude oil	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0
Transport equipment	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	20.7	-0.4	20.7	-0.4	20.7	-0.4
Machinery and equipment	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.0	-0.2	18.0	-0.2	18.0	-0.2
Inland transport	20.8	0.1	20.7	-0.1	20.8	0.1	20.7	-0.1	20.8	0.1	20.8	0.1	20.8	0.1	20.8	0.1
Food and beverages	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.7	0.0	17.7	0.0	17.7	0.0

For the non-ETS sectors, the effect varies among sectors. At least two effects can take place. Sectors, such as *Food and beverage*, which are relatively electricity-intensive relative to the other non-ETS sectors see their output rise as a consequence of auction revenue recycling to support RES. In other sectors, such as *Transport and equipment*, *Manufacturing and equipment*, the impact is hardly visible. *Inland Transport* benefits from this recycling option due to a demand effect from the non-ETS sectors that have to pay the electricity levy and are better off when the latter is reduced. In terms of



competitiveness, we observe no significant impact of this recycling option on the non-ETS sectors' world market shares. The non-ETS carbon price is reduced as a consequence for the non-ETS sectors to use cheaper abatement opportunities, including through a larger use of electricity.

In aggregate for the whole economy, using auction revenues to support RES in electricity production induces a gain in GDP due to the increased output in the non-ETS sectors, which significantly use electricity but are not exempted from the electricity levy.

## **1 Context**

In the last years, the European Commission (EC) has defined its vision for climate and energy policies in the medium- and long-term in different Communications. In its Communication on a policy framework for climate and energy in the period 2020 to 2030 (EC, 2014a), it proposed to reduce greenhouse gas (GHG) emissions in the European Union (EU) by 40% compared to 1990 levels by 2030 and raise the share of renewable energy (RES) in the EU energy mix to at least 27%. Moreover, in the Communication on Energy Efficiency and the contribution to energy security and the 2030 Framework for climate and energy policy (EC, 2014b), it proposed to achieve energy savings of 30% by 2030.

In response to these proposals, in late 2014, the European Council adopted three conclusions on the 2030 targets (EUCCO, 2014). It endorsed (i) a binding EU target to domestically reduce GHG emissions by at least 40% by 2030 compared to the levels of 1990, (ii) a binding target to increase the share of renewable energy consumed in the EU to at least 27% by 2030 and (iii) an indicative target to improve energy efficiency by at least 27% by 2030. The latter will be reviewed in 2020 with the aim to be increased to 30%.

As underlined in the Impact Assessment accompanying the 2030 Framework Communication (EC, 2014c), emissions from the sectors covered by the Emissions Trading System (ETS) need to be cut by around 43% and non-ETS emissions by around 30% (both compared to 2005) to achieve the 40% GHG reduction target efficiently.

More recently, the European Commission has defined a strategy for its Energy Union project (EC, 2015a). This strategy aims at establishing a “resilient Energy Union with an ambitious climate policy” and hence at transforming the EU’s energy system in order to provide “secure, sustainable, competitive and affordable energy” to consumers. Since then, a number of legislative proposals and Communications, grouped into

different packages,<sup>10</sup> have been adopted by the EC to reflect the strategy for the Energy Union project.

In parallel, at the international level, the Paris Agreement entered into force in November 2016. The Parties have submitted their Nationally Determined Contributions (NDC). The facilitative dialogue, which is planned for 2018, will take stock of the collective efforts with regard to the long-term climate objective set by the agreement. This should inform the preparation of the next climate pledges including new or updated 2030 targets, which are to be communicated by the Parties by 2020.

These policy targets will not only affect the EU economy as a whole but will have varying impacts on the EU Member States (MS) and, in particular, on specific sectors. Hence, there is a need to examine the effects of different policy settings that may arise in the mid- and long-term. This report is the achievement of economic modelling work carried out for DG GROW. It aims at analysing the impacts of the EU climate and energy policies on the competitiveness of the European industry. It takes into account the altered EU policy context marked by the publication of the 'Clean Energy for All Europeans' package, the proposal for an Effort Sharing Regulation for 2021-2030 and the proposed revisions of the ETS, as well as international climate negotiations orientated towards the preparation of climate pledges for 2030. The analysis focuses specifically on the impact of various options of carbon auctions revenues recycling under two different assumptions regarding international climate action. The main objective of the study was to quantify the impacts of EU climate and energy policies on the European industry competitiveness under two different levels of implementation of NDCs within the Paris Agreement (unilateral EU action vs international action) and considering two policy options for Member States to use EU ETS revenues (supporting electricity generation from renewable energy vs lump-sum transfer to households). To do so:

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<sup>10</sup> For a complete list, see: [https://ec.europa.eu/commission/priorities/energy-union-and-climate\\_en](https://ec.europa.eu/commission/priorities/energy-union-and-climate_en)

- A baseline scenario was developed with EU emissions as close as possible to the EU 2016 Reference Scenario figures (EC, 2016b), in particular as regards main aggregates (power generation/energy, industry, transport, other services/agriculture and households). This baseline is based on decomposed energy and emissions data for the various sectors represented in the model;
- The possibility was introduced for Member States to use the ETS auctions revenues to support power generation from renewable energy;
- The possibility for Member States to support electricity generation from renewable energy via an electricity levy (paid by electricity consumers) was introduced in the model, as a replacement of the originally modelled public support (paid by tax payers);
- The possibility for Member States to exempt some of their industries from this electricity levy was also developed;<sup>11</sup>

Finally, the aim is to provide a policy analysis to the Directorate General for Internal Market, Industry, Entrepreneurship and Small and Medium enterprises (DG GROW) to allow a better mainstreaming of industrial competitiveness concerns in climate and energy policies. This report presents the final results of the modelling exercise. It covers the model developments and scenario analyses mentioned above. After the model and scenarios are described, the main results are presented and interpreted and finally policy implications are drawn from them.

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<sup>11</sup> The ZEW team has also worked on the representation of energy efficiency improvements related to policy induced technical change. The resources of this project do not allow us to fully develop this in additional scenarios for the current analysis, but the work started could be continued in another contract in order to serve further policy analysis. The associated model development is not presented in this report.

## **2 Model Description**

The quantitative assessment of the 2030 Framework is carried out with PACE (Policy Analysis based on Computable Equilibrium), a multi-sector, multi-region computable general equilibrium (CGE) model of global production, consumption, trade and energy use. PACE is established in economic research and policy consulting and has, for instance, been employed in the previous studies "Sectoral approaches to fostering international action on climate change" and "Broadening the scope of the analysis of the possible risk of carbon leakage induced by the Decarbonisation Roadmap 2050" for DG ENTR. The following gives an overview of PACE's features with a more in-depth model description in Appendix 8.1.

### **2.1 The PACE Model**

The PACE model includes representations of production sectors, consumption, taxation, and trade calibrated to a globally balanced set of social accounting matrices (SAMs). Production sectors take market prices as given and choose input factors (capital, labour, energy, intermediates) such that production costs are minimal. Perfect market competition forces them to sell their produced goods at zero profit. Similarly, representative consumers take market prices as given and choose their consumption such that they get maximum utility out of their budget. The representative households receive revenues from offering the production factors they own (labour, capital, and resources) to the production sectors. In the model version used in this study, we assume one representative household per region. Prices of all produced commodities and production factors are set such that markets for the respective goods clear. Governments raise taxes to finance fixed amounts of government services and transfer net surpluses to households.

In order to discuss climate policy, the PACE model tracks the value flows of energy commodities: crude oil, refined oil, natural gas, coal, nuclear power, renewable energy sources and electricity. The use of the fossil fuels refined oil, natural gas, and coal in production and consumption are linked to CO<sub>2</sub>

emissions from burning those fuels for the production of energy. The model thus only considers CO<sub>2</sub> emissions, namely those from fossil fuel combustion and process emissions.<sup>12</sup> PACE adds emission permits as a resource owned by the governments and lets market clearance conditions determine the price at which the fixed supply meets demand. In case of the EU ETS, permits may be traded across the EU for use by industrial sectors included in the EU ETS. Emissions in non-EU countries are governed by national policies and are non-tradable across regions, but free markets guarantee that all emitters face the same carbon price within each country.<sup>13</sup> In order to best represent the Effort Sharing Decision, we assume trading of fictitious non-ETS permits across regions so that marginal abatement costs in those sectors are equalized.

Unless otherwise stated, revenues from non-ETS carbon pricing (through endogenous carbon taxes) go to the government and are refunded to the national representative households. Revenues from EU ETS permit auctions also accrue to the government, but freely allocated ETS permits are handed to the owners of the respective production facilities. Production with these freely allocated permits is not assumed to generate windfall profits for their owners due to perfect competition within the respective sectors.

## **2.2 Model Development**

The PACE model has been developed further. The baseline scenario has been improved. In order to simulate alternative options to use carbon auctions revenues, the ZEW team introduced the possibility for Member States to (i) support electricity generation from renewable energy via an electricity levy, (ii) exempt some of their industrial sectors from this levy and, (iii) use part of the carbon auctions revenues to subsidize electricity generation from renewable energy and hence reduce this levy.

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<sup>12</sup> See Appendix 8.2 for details.

<sup>13</sup> Note that the policy instruments chosen in these countries or the sector specific policies chosen in EU Member states may have a significant impact on the results. We do not include this level of detail in the analysis.

The baseline has been improved in order to align EU emissions of each main aggregate sector (power generation/energy, industry, transport, other services/agriculture and households) as closely as possible with the EU 2016 Reference Scenario figures (EC, 2016). This has involved decomposing energy and emissions data from this scenario for the various sectors represented in the model to replace the data currently used. For further details, we refer you to section 2.3 on data and calibration and section 3.1 on the baseline scenario.

Regarding the use of carbon auctions revenues, the default option used in the past projects was to return them to households in lump-sum rebates. The model has now been developed to allow Member States to use these revenues to support electricity production from renewable energy. In the model, this is represented by transferring auctions revenues to the electricity sector as a subsidy for production from renewable energy.<sup>14</sup>

A meaningful simulation of this additional option to recycle ETS auctions revenues required to improve the representation of the support to power generation from renewable energy in PACE. In the original version of the model, Member States reach their renewable energy objectives in the power sector by public support (paid by tax payers). However, in reality, in several Member States, renewable energy support in the electricity sector is covered by an electricity levy (paid by electricity consumers).<sup>15</sup> The model was hence developed by introducing an endogenous tax on electricity consumption in order for the associated revenues to cover the support

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<sup>14</sup> Alternative options considered were to subsidize capital for electricity production from renewable energy or to reduce labour cost. Regarding the first alternative, technology-specific capital in the electricity sector (bottom-up module) of PACE is considered as a fixed factor, hence it is available in fixed supply. In this case, a subsidy to technology-specific capital only increases the corresponding rents. Regarding the second alternative, the model currently assumes full employment and a fixed labour supply for each region. Under these circumstances, a labour subsidy only results in higher wages for employees.

<sup>15</sup> For recent information on how Member States support renewable electricity, we refer the reader to the RES LEGAL website: [www.res-legal.eu](http://www.res-legal.eu).

needed by each Member State and to make it possible for the EU to reach its renewable energy objective in the power sector.

As in many Member States, energy intensive industries are actually exempted from this kind of levy,<sup>16</sup> the ZEW team introduced the possibility for Member States to exempt some industrial sectors from this electricity levy.

### **2.3 Data and Calibration**

For this report, the PACE model is calibrated using the globally harmonized Social Accounting Matrices (SAMs) for the reference year 2011 provided in the GTAP 9.1 data set of the global trade analysis project (GTAP). Regional and sectoral coverage used for the model are reported in Table 6 and Table 7, respectively.

Within the European Union we consider the five largest economies of the Western European Member States (Germany, France, the United Kingdom, Italy and Spain) as well as Poland as the largest economy of the Eastern European Member States as separate regions. The remaining EU countries are gathered in two groups: “Rest of Western MS”, “Rest of Eastern MS”.<sup>17</sup>

The most significant developed and developing economies outside the EU are included as separate regions as well. Here, we focus on the separate representation of large developed economies, such as the United States, Canada and Japan, as well as on the BRICS countries.

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<sup>16</sup> For an international comparison of exemptions from electricity taxes and levies, we refer the reader to Fraunhofer and Ecofys (2015).

<sup>17</sup> In the model, this means that the data for all countries in each of these two regions are aggregated.



**Table 6:** Regional coverage of the PACE model

EU regions:	
DEU	Germany
FRA	France
GBR	United Kingdom
ITA	Italy
ESP	Spain
POL	Poland
XWE	Rest of Western MS (Denmark, Sweden, Finland, Austria, Belgium, Netherlands Luxembourg, Ireland, Portugal, Greece, Malta, Cyprus)
XEE	Rest of Eastern MS (Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Romania, Croatia, Estonia, Latvia, Lithuania)
USA	United States of America
CAN	Canada
JPN	Japan
RUS	Russia
AUS	Australia
TUR	Turkey
RAX	Switzerland, Norway, Iceland, Liechtenstein, Ukraine, Belarus, New Zealand
CHN	China (incl. Hong Kong, excl. Taiwan)
IND	India
BRA	Brazil
KOR	South Korea
IDN	Indonesia
MEX	Mexico
ZAF	South Africa
ROW	Rest of the World

Regarding the sectoral coverage, the model version used distinguishes 36 production sectors, which include five for extractive activities, 26 for industrial activities and five for services.

Where sectoral coverage of the GTAP 9.1 database was not sufficient, we disaggregated the sectors using additional data sources. Appendix 8.2 provides a more detailed description of the disaggregation procedure.

**Table 7: Sectoral coverage of the PACE model**

Main aggregates	Sectors
Extractive activities	Agriculture, forestry and fishing
	Coal production
	Crude oil extraction
	Natural gas extraction
	Mining, n.e.c.
Industry covered by EU ETS	Pulp and paper
	Refineries and coke oven production
	Fertiliser production
	Organic chemical production
	Inorganic chemical production
	Cement production
	Bricks and tiles production
	Glass production
	Ceramics production
	Basic iron and steel production
	Further processing of iron and steel
	Aluminium production
	Production of other non-ferrous metals
	Air transport
Electricity	
Industry not covered by ETS	Food production
	Manufacture of textiles, wearing apparel and leather
	Manufacture of wood and wood products
	Other chemicals, rubber, plastics production
	Production of other non-metallic minerals
	Manufacture of electrical and electronic equipment
	Manufacture of machinery and equipment, n.e.c.
	Motor vehicles and parts
	Other transport equipment
	Other manufacturing
	Construction

Main aggregates	Sectors
Other services	Inland transport
	Water transport
	Business services
	Private services
	Public services

To account for economic growth, we scaled the national endowments of production factors according to country specific GDP growth projections. To account for technological progress, we modelled energy efficiency increases as declining energy requirements for production in different industries and in consumption. For different assumptions about the prices of energy goods, the availability of resources for the production of the energy goods was adjusted until the market prices were in line with the baseline projections. A baseline scenario was thus established for the model periods 2010 to 2030 using five-year time-steps.

In the case of the EU, the EU Reference Scenario 2016<sup>18</sup> was used to calibrate GDP, industrial energy efficiency improvements and developments in consumption of specific fuels by the power sector. On the policy side, the results from the Reference 2016 Scenario informed the assumptions about ETS permit prices in the baseline. Projections of fossil fuel prices in the Reference 2016 Scenario were used to inform global market prices for fuels. GDP and energy efficiency improvements of non-EU countries were projected according to the International Energy Outlook of the US Department of Energy (International Energy Outlook –IEO- 2013). At the sectoral level, the projections provided by the Reference 2016 Scenario are not as detailed as the PACE version used for this project. Therefore, Reference 2016 parameters with sectoral detail are disaggregated according to the corresponding shares of each PACE sector within the respective aggregate Reference 2016 sector. In particular, data on energy demand are

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<sup>18</sup> For reasons of readability, EU Reference Scenario 2016 and Reference 2016 will be used analogously.

considerably more detailed in the 2013 IEO and in GTAP than in the aggregated Reference 2016 projections used for the calibration of the PACE model. CO<sub>2</sub> profiles are computed using demand for fossil fuels. To combine the advantages of both data sources, we use the growth rates of sectoral energy demands, not their absolute values, from Reference 2016 projections, whereas the fuel mix in each sector is computed according to IEO information. Nevertheless, we decompose the aggregate information on fossil fuel use provided in Reference 2016 using consumption shares from the IEO projections. To this end, we use energy inputs of the Reference 2016 scenario for the base year 2010 which are provided by fuel type for aggregate sectors (e.g. industry, electricity). To achieve such a sectoral coverage as in the PACE model we use sectoral shares from GTAP and the IEO to decompose them for all model sectors. The temporal development, however, follows that of the model since it is identified endogenously.

Note, however, that emissions in the PACE baseline scenario cannot completely match with the Reference 2016 emissions. This is due to the fact that CO<sub>2</sub> emissions rely not only on input values from external data sources but are endogenously computed within the model by using intermediate inputs from fossil fuels to the model sectors. Hence, the final outcome for this model variable depends on many other endogenous model variables and interrelations.

Process emissions were included for all model sectors in all model regions. To this end, we made use of process emissions data from the World Input Output Database (WIOD).<sup>19</sup> The advantage of this database is that the sectors are relatively similar to the PACE sectors and can thus be translated in a relatively straightforward fashion.

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<sup>19</sup> [http://www.wiod.org/new\\_site/home.htm](http://www.wiod.org/new_site/home.htm)

### 3 Scenario Description

This section introduces the baseline scenario as well as the policy scenarios used in this study. Most of the results are presented as changed vis-à-vis the baseline scenario.

#### 3.1 Baseline Scenario

The starting point is the baseline, which was applied in the main part of the project “EU Competitiveness and the 2030 Framework – An Industry Perspective”, carried out for EASME and the DG GROW from 2015 to 2016. It includes:

- EU CO<sub>2</sub> emissions reduction of 28% by 2030 compared to 1990 levels,
- Emissions reductions in other regions according to GECO (Global Energy and Climate Outlook) 2015 (2020 Copenhagen Pledges),
- 20% renewable energy share in gross final energy consumption by 2020, which corresponds to 35% in the electricity sector,
- Free allocation to sectors on the carbon leakage list at all times, cross sectoral correction factor if needed, auctioning in other cases,<sup>20</sup>
- Lump-sum transfer of auctioning revenues to households,
- No emissions permits trading in non-EU countries.

This baseline scenario is built on GTAP 9.1 data and the EU Reference 2016 Scenario, so that EU energy and emissions figures are as close as possible to those of the latter.

The time horizon of this baseline is the period up to 2030.

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<sup>20</sup> No free allocation is allowed in the power sector.

**Table 8:** Share of CO<sub>2</sub> emissions from installations affected by benchmark

Sector	Share in % of CO <sub>2</sub> emissions from a installations affected by benchmark
Refined oil products	86%
Cement	92%
Bricks, tiles and construction products	70%
Glass	40%
Ceramics	40%
Iron and steel – manufacturing	91%
Iron and steel – further processing	40%
Aluminium	80%
Other non-ferrous metals	40%
Fertilisers	74%
Organic chemicals	63%
Inorganic chemicals	63%
Pulp and paper	77%
Air transport	40%

Permits are freely allocated up to a sector specific benchmark to sectors included in the carbon leakage list and the corresponding revenues of the auctioned allowances are recycled via lump-sum transfer to households. To implement the sector-specific benchmarks into the PACE model, we need to calculate the share of CO<sub>2</sub> emissions of the installations affected by the benchmark. To this end, we consulted findings from a previous project for DG ENTR.<sup>21</sup> These shares are given in Table 8.

We improved the baseline scenario, in particular by ensuring that the emissions of each main aggregate (power generation/energy, industry, transport, other services/agriculture and households) are as close as possible to those of the EU 2016 Reference Scenario. To this end, the project team decomposed EU energy and emissions figures from the EU Reference

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<sup>21</sup> “Sectoral approaches to fostering international action on climate change”, Service contract SI2.548488, Öko-Institut, ZEW (2010)

Scenario for the various economic sectors in order to replace the GTAP data used previously.

The surplus of emissions allowances – which has accumulated in recent years – and the Market Stability Reserve are imposed in an exogenous manner as in the previous report.

### 3.2 Policy Scenarios

The project team has developed and analysed four stylised policy scenarios, and two variants of each to assess the impact of the 2030 framework for climate and energy policies on the competitiveness of the European industry, while taking into account the latest development of the EU ETS, the new Effort Sharing Regulation and international climate negotiations (Paris Agreement). The analysis examines policy impacts at the regional and sectoral level.

For the EU, all policy scenarios include the following features:

- 40% carbon dioxide emissions<sup>22</sup> reduction by 2030 compared to 1990 levels (corresponds to respectively 43% and 30% in the ETS and non-ETS sectors below 2005 levels),<sup>23</sup>
- 27% renewable energy in total energy consumption by 2030, target reflected at Member State level by an increase in the share of renewable energy in the electricity sector (RES-E) in line with potential contribution of electricity sector to overall RES share,<sup>24</sup>

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<sup>22</sup> Energy and non-energy related emissions.

<sup>23</sup> Note that the PACE model only considers CO<sub>2</sub> emissions. Policy targets are set for GHG emissions in general. In this study, we assume that the respective targets apply to CO<sub>2</sub> emissions.

<sup>24</sup> Since the PACE model represents renewable energy only in the electricity sector, this target is translated into a share of renewable energy in the electricity sector of 45% by 2030. Regarding the split per Member State, it is based on the EUCO30 scenario. However, it

- 2.2% linear reduction factor for the EU ETS cap for the time period 2021-2030,
- Free allocation up to sector specific benchmark in sectors on the carbon leakage list,<sup>25</sup> auctioning according to EU ETS regulation in the other cases (full auctioning<sup>26</sup> in the electricity sector; 30% of free allocations up to a sector-specific benchmark in 2020 and beyond for the other sectors), 1% flat rate to benchmark for the sectors on the carbon leakage list,<sup>27</sup>
- Auctioning of at least 57% of emissions allowances and the rest for free for the time period 2021-2030,<sup>28</sup>
- Distribution of efforts in the non-ETS sectors among Member States according to the new Effort Sharing Regulation.<sup>29</sup>

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should be noted that this split is purely indicative, since Member States will have the possibility to propose national contributions towards the EU RES target in their forthcoming national energy and climate plans.

<sup>25</sup> This list includes the following sectors: Refined oil and coal products/ Crude oil extraction/ Cement/ Bricks, tiles and construction products/ Glass/ Ceramics/ Manufacturing of iron and steel/ Aluminium/ Fertilizers and other nitrogen compounds/ Organic chemicals/ Inorganic chemicals/ Paper, pulp and printing products. This list mirrors the carbon leakage list of the European Commission (2014/746/EU, Annex, Commission Decision of 27 October 2014) to the extent possible given the sectoral coverage of the model in comparison to the very detailed (NACE 4 classification) original list.

<sup>26</sup> However, eight new Member States make use of derogation under Article 10c of the EU ETS directive, which allows them to issue a decreasing number of free allowances in the electricity sector. Some of these MS will even make use of this option beyond 2020 ([http://ec.europa.eu/clima/policies/ets/cap/auctioning/in-dex\\_en.htm](http://ec.europa.eu/clima/policies/ets/cap/auctioning/in-dex_en.htm)). We do not take this into account in our scenario assumptions.

<sup>27</sup> This means that, in 2025 and 2030, these sectors respectively receive only 85% and 80% of the respective benchmark allowances (based on 2007/2008 data) for free.

<sup>28</sup> The actual share of auctioned allowances in all scenario simulations is approximately 74%.

<sup>29</sup> In practice we do not fully represent each MS target but the reductions in the non-ETS sectors are simulated by carbon trading between those sectors, in order to represent the fact that the Effort Sharing Regulation is driven by an attempt to equalize costs between Member States. This explains why we report a carbon price for the non-ETS sectors in the report.



- Table 9 summarizes the renewable energy targets translated for the electricity sector based on the EUCO30 scenario (cf. footnote 24). The targets for the aggregate regions (Rest of Western MS, Rest of Eastern MS) were identified by computing the weighted average with electricity demand.

**Table 9:** Assumed renewable energy targets in electricity sector based on EUCO30 scenario

Model region	2020	2025	2030
France	31.5	36.4	37.2
Germany	34.9	37.6	45.6
Italy	32.5	44.9	51.9
Poland	14.3	20.7	26.5
Spain	38.5	54.9	68.8
United Kingdom	41.1	46.7	49.9
Rest of Western MS	47.5	53.1	62.1
Rest of Eastern MS	23.0	28.3	36.3

The specific reduction targets for each model year are given in Table 10 and follow the EU Decarbonisation Roadmap.

The ratio between issued ETS permits and non-ETS emissions is kept at the level given by the baseline scenario.<sup>30</sup> Within the ETS sectors, full trade of allowances between all EU Member States is implemented such that the cost efficient allocation of permits to each member state and sector is eventually achieved. As mentioned previously, in order to mimic the Effort Sharing Regulation, carbon trading between Member States in non-ETS sectors is also implemented.

In order to take into account the structural surplus and the MSR, we follow the assumptions outlined in the description of the baseline scenario in Section 3.1. Hence, the surplus and the MSR are used in the model years

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<sup>30</sup> This assumption leads to a CO<sub>2</sub> emissions reduction in ETS and non-ETS sectors close to that foreseen in the Impact Assessment of the 2030 Framework: 42% in ETS sectors vs. the 2005 level and 30% in non-ETS sectors vs. the 2005 level.

after 2030 (no use beforehand). The surplus and the MSR are assumed to be completely exhausted by 2050.<sup>31</sup>

**Table 10:** Pathway to achieve reduction targets in the EU

Year	Reduction targets vs. 1990 (%)
2005	7
2010	12
2015	18
2020	25
2025	33
2030	40

The revenues from the carbon auctions are either handed back to the consumers via lump sum transfers, or used to subsidize renewable energy production (cf. specific scenarios description below).

The project team has developed and analysed four stylised policy scenarios (summarizing overview in Table 1):

*Scenario int:*

- Non-EU regions comply with their NDCs by the respective announced year (2025/2030).
- Lump-sum transfer of auction revenues to households.

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<sup>31</sup> Note that the overall cap (total EU ETS emissions over the period 2005-2030) always holds and is never exceeded in any policy scenario. The consumption of the accumulated allowance surplus only means a transfer of emissions from one period to another one (flexibility of the EU ETS instrument).

*Scenario uni:*

- Non-EU regions implement their NDC objectives by 2020 but do not conduct additional policy beyond (no emissions constraints beyond 2020).
- Lump-sum transfer of auction revenues to households.

*Scenario int\_ren:*

- Non-EU regions comply with their NDCs by the respective announced year (2025/2030).
- Member States use 100% of the auctions revenues to subsidize electricity production from renewable energy.

*Scenario uni\_ren:*

- Non-EU regions implement their NDC objectives by 2020 but do not conduct additional policy beyond (no emissions constraints beyond 2020).
- Member States use 100% of the auctions revenues to subsidize electricity production from renewable energy.

When a reduction range was given in the respective NDC, we implemented the lower reduction target. The specific NDCs and adjusted targets for each model region are depicted in Table 11. As the European Union expresses its CO<sub>2</sub> emissions reduction targets in comparison to 1990 levels, we implement the reduction policies in non-EU regions for the different scenarios in this manner.

In these four scenarios, the assumptions regarding electricity levy and potential exemptions are the following:

- in the United Kingdom and Poland, 100% of the support for renewable energy investments in the power sector is paid by tax payers;<sup>32</sup>
- in the rest of the Western Member States region, 50% of it is paid by tax payers and 50% by electricity consumers (via the electricity levy);<sup>33</sup>
- In the other EU regions, 100% is covered by the electricity levy;
- In the regions where an electricity levy is used, industries covered by the ETS are exempted.

Two variants of these four main scenarios were added to the analysis:

In variant (1) of these four scenarios, we assume that all Member States have an electricity levy that covers 100% of the RES support, and that all sectors covered by the ETS are exempted.

In variant (2), we assume that all Member States also have an electricity levy that covers 100% of the RES support, but that all sectors (including those covered by the ETS) pay for this levy.

The results we expect from such varying assumptions on the RES electricity levy and exemptions are the following.

In countries where RES is fully paid by tax payers, the differences between a scenario in which ETS auctions revenues are transferred to households and a scenario in which they are used to subsidize power generation from renewable energy should be negligible. The reason is that, in the first case,

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<sup>32</sup> We make this assumption since in the UK and in Poland RES targets are achieved completely by public support. This also applies to Finland which is however part of the aggregate region “Rest of Western MSs” in this study.

<sup>33</sup> In this model aggregate region, the situation varies between Member States (Finland, the Netherlands, Sweden and Malta do not report the use of an electricity levy to support renewable energy), hence the assumption of 50%. For more details on electricity taxes and levies, we refer the reader to the European Commission report on *Energy prices and costs in Europe* and its working document (EC, 2016c).

it is the same entity that pays for renewable energy support and receive auctions revenues.

In countries where an electricity levy is used, sectors that are not exempted should be better off if auctions revenues are used to support renewable electricity (as the levy can then be reduced) than if they are transferred to households. Sectors that are exempted should be impacted only via the general equilibrium effects in the whole economy (via changes in electricity and fossil fuel prices for example).

Unless otherwise stated, the results will be presented as changes vis-à-vis the reference baseline scenario outlined in the previous section.

**Table 11:** NDCs and adjusted reduction targets of CO<sub>2</sub> emissions

				NDC	GECO 2015 Emissions Target Year			POLES Total CO <sub>2</sub> Base year	Emissions in targeted year, scenario with INDCs introduced in PACE		Reduction target vs 1990 for PACE (% change vs. 1990)	Comments
	Base year or reference	Target year	CO <sub>2</sub> from fuel combustion in 1990		Total CO <sub>2</sub>	CO <sub>2</sub> from fuel combustion	Share		Total CO <sub>2</sub>	Emissions from fuel combustion		
EU	1990	2030		40 percent								
Australia	2005	2030	285	26-28 percent	688	523	0,7598	643	475,630	361,402	26,98	
Japan	2005	2030	1015	25,4 percent	1102	985	0,8942	1339	998,529	892,946	-11,99	
Canada	2005	2030	428	30 percent	785	646	0,8226	760	532,149	437,771	2,31	
United States	2005	2025	4908	26-28 percent	5924	4979	0,8406	6950	5142,808	4323,124	-11,92	
Brazil	2005	2025	187	37 percent	1415	631	0,4461	2343	1475,872	658,419	251,61	For 2030, we use the indicative INDC, i.e. 43% vs. 2005

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				NDC	GECO 2015 Emissions Target Year			POLES Total CO <sub>2</sub> Base year	Emissions in targeted year, scenario with INDCs introduced in PACE		Reduction target vs 1990 for PACE (% change vs. 1990)	Comments
	Base year or reference	Target year	CO <sub>2</sub> from fuel combustion in 1990		Total CO <sub>2</sub>	CO <sub>2</sub> from fuel combustion	Share		Total CO <sub>2</sub>	Emissions from fuel combustion		
Russia	1990	2030	2306	25-30 percent	2344	1692	0,7216	3292	2468,666	1782,276	-22,71	
Korea	BAU	2030	225	37 percent	697	590	0,8452	697	439,415	371,407	65,33	
Indonesia	BAU	2030	166	29 percent unconditional	1413	524	0,3710	1413	1003,374	372,242	123,98	
Mexico	BAU	2030	281	25 percent unconditional	795	566	0,7121	795	596,508	424,790	51,20	
Turkey	BAU	2030	122	21 percent	615	440	0,7150	615	485,878	347,426	184,50	
South Africa	-	2025	281	614 MtCO <sub>2</sub> e	575	470	0,8174	-	575	470	67,27	use baseline because higher cap is above baseline

				NDC	GECO 2015 Emissions Target Year			POLES Total CO <sub>2</sub> Base year	Emissions in targeted year, scenario with INDCs introduced in PACE		Reduction target vs 1990 for PACE (% change vs. 1990)	Comments
	Base year or reference	Target year	CO <sub>2</sub> from fuel combustion in 1990		Total CO <sub>2</sub>	CO <sub>2</sub> from fuel combustion	Share		Total CO <sub>2</sub>	Emissions from fuel combustion		
China	2005	2030	2300	60-65 percent (carbon intensity)	15644	12881	0,8234	5893	14177	11673,402	407,54	
India	2005	2030	553	33-35 percent (carbon intensity)	3973	2671	0,6723	2089		3014	445,03	is higher than POLES and GECO baseline; therefore we use GECO baseline values
Rest of Annex I											-40	Most countries have 40 percent reduction vs.



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				NDC	GECO 2015 Emissions Target Year			POLES Total CO <sub>2</sub> Base year	Emissions in targeted year, scenario with INDCs introduced in PACE		Reduction target vs 1990 for PACE (% change vs. 1990)	Comments
	Base year or reference	Target year	CO <sub>2</sub> from fuel combustion in 1990	NDC	Total CO <sub>2</sub>	CO <sub>2</sub> from fuel combustion	Share		Total CO <sub>2</sub>	Emissions from fuel combustion		
												1990, especially the large ones
ROW	BAU	2030	6205		14753	9137	0,6194	14753	14015,064	8680,5864	39,89	

## 4 Modelling Results

### 4.1 Baseline Scenario

Table 12 presents macroeconomic and environmental indicators for the EU model regions and the EU28 aggregate in 2030. These figures will serve as the reference point for the policy scenarios analysed in the following subsection.

**Table 12:** Selected macroeconomic and environmental indicators in baseline scenario – 2030

<b>Macroeconomic and environmental ind.</b>	France	Germany	Italy	Poland	Spain	United Kingdom	Rest of Western MS	Rest of Eastern MS	<b>EU28</b>
GDP (trillion 2010 €)	2.51	3.23	1.87	0.55	1.35	2.25	3.40	0.87	<b>16.07</b>
Consumption (trillion 2010 €)	1.45	1.94	1.14	0.341	0.801	1.514	1.91	0.534	<b>9.65</b>
CO2 emissions (Gt)	0.310	0.597	0.334	0.267	0.207	0.304	0.52	0.311	<b>2.85</b>
ETS	0.089	0.311	0.137	0.140	0.080	0.088	0.21	0.147	<b>1.20</b>
CO2 price ETS (2010 €)	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	<b>33.3</b>
Primary energy consumption (EJ)	9.63	12.02	6.85	4.45	5.16	7.225	12.9	6.84	<b>65.1</b>

**Table 13:** EU total and sectoral CO<sub>2</sub> emissions for PACE and PRIMES reference baselines.

	Mt CO <sub>2</sub> emissions			% change
	2010	2020	2030	'20->'30
<b>PACE aggregated</b>				
<b>Total CO<sub>2</sub> emissions</b>	<b>3617</b>	<b>3179</b>	<b>2809</b>	<b>-11.6</b>
Power generation/District heating	1303	961	639	-33.5
Energy branch <sup>34</sup>	177	175	191	8.9
Industry (including non-energy related CO <sub>2</sub> emissions) <sup>*35</sup>	499	552	539	-2.3
Tertiary & Agriculture	267	244	234	-3.8
Transport sector excl. water*	355	386	400	3.8
Households*	1000	846	789	-6.8

\* Based on PRIMES data

	Mt CO <sub>2</sub> emissions			% change
	2010	2020	2030	'20->'30
<b>PRIMES</b>				
<b>Total CO<sub>2</sub> emissions</b>	<b>4020</b>	<b>3529</b>	<b>3068</b>	<b>-13.1</b>
Power generation/District heating	1344	1059	865	-18.3
Energy branch	155	133	112	-15.5
Industry (including non-energy related CO <sub>2</sub> emissions)	749	749	600	-20.0
Tertiary & Agriculture	268	221	183	-17.0
Transport sector excl. water	408	437	448	2.5
Households	1078	916	844	-7.9

<sup>34</sup> These emissions mainly come from the sector *Refined oil and coal products*. In PACE, this sector is growing at a much higher rate than in PRIMES, which explains the difference in emissions trend between PACE and PRIMES. However, this concerns a relatively small share of total CO<sub>2</sub> emissions.

<sup>35</sup> The differences between PACE and PRIMES in the industry branch are related to a different representation of process emissions. Whereas they decrease rapidly in PRIMES, they remain relatively constant in PACE.

Table 13 presents a comparative overview of total and sectoral CO<sub>2</sub> emissions for the PACE and PRIMES reference baselines. There are still differences between both baselines compared to the previous report, in particular with respect to sectoral emission figures. However, these differences were minimized. As stated previously, emissions in the PACE baseline scenario cannot completely match with the Reference 2016 emissions. This is due to the fact that CO<sub>2</sub> emissions rely not only on input values from external data sources but are endogenously computed within the model by using intermediate inputs from fossil fuels to the model sectors. Hence, the final outcome for this model variable depends on many other endogenous model variables and interrelations.

## **4.2 Policy Scenarios**

The macroeconomic and sectoral results of the policy scenarios are presented on the following three pages: Table 14 shows macroeconomic and environmental indicators for all scenarios in 2030 for the EU28 aggregate,<sup>36</sup> Table 15 presents the sectoral output changes <sup>37</sup>and Table 16 shows the world market shares for each sector. For convenience, we only show selected scenarios and sectors in the main part of the report. The full results as well as additional indicators are presented in Table 17 and Table 26 to Table 37 in Appendix 8.3. To explain these results, we examine how the scenario specific features influence energy prices and demand, the output of the industrial sectors in consequence, and finally the carbon price and GDP in the EU.

In the first subsection, we investigate the impact of international action compared to unilateral action. In the second subsection, we similarly examine the effect of using auction revenues to support electricity generation from renewable energy.

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<sup>36</sup> The respective results for the EU model regions in 2030 are presented in Table 18 to Table 25 in Appendix 8.3.

<sup>37</sup> Changes in sectoral revenues and sectoral employment are reported in Appendix 8.3.

**Table 14:** Selected macroeconomic and environmental indicators for policy scenarios – EU28 aggregate in 2030

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	int_ren_1	int_2	int_ren_2
CO2 emissions (Gt)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
Including ETS emissions (Gt)	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	75.3	74.0	75.1
CO2 price non-ETS (2010 €)	180	159	173	153	187	176	182	174
Free allowance share (%)	26.6	26.0	26.6	26.0	26.6	26.6	26.6	26.6
Change in consumption (trillion 2010 €)	0.011	-0.027	0.011	-0.028	0.013	0.012	0.012	0.012
GDP (% change vs. baseline)	-0.7	-0.9	-0.6	-0.9	-0.7	-0.6	-0.7	-0.6
CO2 emissions (% change vs. baseline)	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9
Including ETS emissions (Gt)	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6
Energy demand (% change vs. baseline)	-6.5	-8.2	-6.1	-7.9	-7.0	-6.3	-7.0	-6.4
Electricity demand (% change vs. baseline)	3.1	2.0	4.4	3.1	1.7	3.7	1.3	3.5
Primary energy consumption (% change vs. baseline)	-4.7	-7.0	-4.3	-6.8	-5.5	-4.6	-5.7	-4.7
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.1	-0.3	0.1	-0.3	0.1	0.1	0.1	0.1

**Table 15:** Selected results of changes in sectoral output (% change vs. baseline) – EU28 aggregate in 2030

<b>Sectoral output (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	int_ren_1	int_2	int_ren_2
Refined oil and coal products	2.5	-1.1	2.6	-1.2	2.1	2.4	1.7	2.2
Paper, pulp and printing	0.0	-0.2	-0.1	-0.2	0.0	-0.1	-0.4	-0.2
Fertilizers	0.9	-2.0	1.1	-1.9	0.8	1.0	0.7	1.0
Organic chemicals	2.8	-1.5	2.9	-1.4	2.8	2.8	2.4	2.7
Inorganic chemicals	1.0	-1.3	1.1	-1.2	0.9	1.0	0.7	0.9
Other chemicals, rubber, plastic	0.3	-3.9	0.7	-3.5	-0.1	0.5	0.2	0.7
Cement	0.2	-0.7	0.1	-0.8	0.2	0.1	-0.2	0.0
Bricks, tiles, construction products	0.4	-1.2	0.3	-1.3	0.4	0.3	-0.1	0.1
Glass	-0.3	-2.2	-0.4	-2.3	-0.2	-0.3	-0.8	-0.6
Ceramics	-1.4	-2.3	-1.5	-2.3	-1.4	-1.5	-1.9	-1.8
Other non-metallic minerals	-5.2	-5.9	-4.9	-5.7	-5.6	-5.0	-5.4	-5.0
Iron and steel - manufacturing	-1.5	-2.3	-1.7	-2.5	-1.4	-1.6	-2.7	-2.3
Iron and steel - further processing	-3.7	-6.2	-4.0	-6.5	-3.6	-3.9	-5.2	-4.7
Aluminium	-0.5	-1.5	-0.8	-1.8	-0.5	-0.8	-3.2	-2.3
Other non-ferrous metals	-1.3	-2.2	-1.5	-2.3	-1.2	-1.5	-3.2	-2.5
Electricity	1.1	-0.1	2.3	0.9	-0.5	1.5	-0.7	1.4
Air transport	1.1	-4.0	1.0	-4.1	1.2	1.1	1.0	1.0
Crude oil	-1.5	-0.7	-1.4	-0.6	-1.6	-1.5	-1.6	-1.5
Transport equipment	-2.4	-0.1	-2.3	-0.1	-2.4	-2.4	-2.3	-2.3
Machinery and equipment	-1.6	-0.1	-1.6	-0.1	-1.6	-1.6	-1.6	-1.6
Inland transport	-2.9	-3.9	-2.7	-3.7	-3.1	-2.8	-3.0	-2.8
Food and beverages	-1.3	-1.1	-1.2	-1.1	-1.3	-1.2	-1.2	-1.2

**Table 16:** Selected sectoral shares in global market and changes in percentage points compared to baseline – EU28 aggregate in 2030

<u>World market share</u>	int		uni		int_ren		uni_ren		int_1		int_ren_1		int_2		int_ren_2	
Refined oil and coal products	19.9	0.6	19.3	-0.1	19.9	0.6	19.3	-0.1	19.8	0.5	19.9	0.5	19.8	0.5	19.9	0.5
Paper, pulp and printing	23.8	0.1	23.7	-0.1	23.8	0.1	23.7	-0.1	23.8	0.1	23.8	0.1	23.8	0.1	23.8	0.1
Fertilizers	11.3	0.1	11.0	-0.2	11.3	0.2	11.0	-0.2	11.3	0.1	11.3	0.2	11.3	0.1	11.3	0.2
Organic chemicals	14.3	0.4	13.8	-0.2	14.4	0.4	13.8	-0.2	14.3	0.4	14.4	0.4	14.3	0.3	14.3	0.4
Inorganic chemicals	14.4	0.1	14.2	-0.2	14.5	0.1	14.2	-0.1	14.4	0.1	14.5	0.1	14.4	0.1	14.5	0.1
Other chemicals, rubber, plastic	17.8	0.2	17.1	-0.5	17.9	0.3	17.2	-0.4	17.8	0.2	17.9	0.3	17.8	0.2	17.9	0.3
Cement	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0
Bricks, tiles, construction products	16.2	0.1	16.1	-0.1	16.2	0.1	16.1	-0.1	16.2	0.1	16.2	0.1	16.2	0.0	16.2	0.0
Glass	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.6	0.1	13.6	0.1	13.6	0.1
Ceramics	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0
Other non-metallic minerals	10.5	-0.1	10.4	-0.1	10.5	0.0	10.4	-0.1	10.5	-0.1	10.5	0.0	10.5	-0.1	10.5	-0.1
Iron and steel - manufacturing	7.6	0.0	7.5	-0.1	7.6	-0.1	7.5	-0.1	7.6	0.0	7.6	-0.1	7.5	-0.1	7.5	-0.1
Iron and steel - further processing	12.1	-0.2	11.8	-0.5	12.1	-0.2	11.8	-0.5	12.1	-0.2	12.1	-0.2	12.0	-0.3	12.0	-0.3
Aluminium	9.3	0.0	9.2	-0.1	9.3	0.0	9.1	-0.1	9.3	0.0	9.3	0.0	9.1	-0.2	9.2	-0.1
Other non-ferrous metals	10.0	-0.1	9.9	-0.2	10.0	-0.1	9.9	-0.2	10.0	0.0	10.0	-0.1	9.9	-0.2	9.9	-0.1
Electricity	16.5	-0.6	17.8	0.6	17.0	-0.1	18.3	1.2	16.2	-0.9	16.8	-0.3	16.1	-1.0	16.8	-0.3
Air transport	22.9	0.2	22.3	-0.4	22.9	0.2	22.3	-0.5	23.0	0.2	22.9	0.2	22.9	0.2	22.9	0.2
Crude oil	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0
Transport equipment	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	20.7	-0.4	20.7	-0.4	20.7	-0.4
Machinery and equipment	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.0	-0.2	18.0	-0.2	18.0	-0.2
Inland transport	20.8	0.1	20.7	-0.1	20.8	0.1	20.7	-0.1	20.8	0.1	20.8	0.1	20.8	0.1	20.8	0.1
Food and beverages	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.7	0.0	17.7	0.0	17.7	0.0

#### 4.2.1 International vs unilateral action

In this subsection, we examine the effect of international climate action on the EU. We compare the scenarios in which non-EU regions comply with their NDC objectives until 2020, but do not have emission constraints afterwards, with scenarios in which these regions have climate objectives until 2030.<sup>38</sup>

When the results observed on *int* and *uni* scenarios follow the same pattern as for *uni\_ren* and *int\_ren* and the variants (1) and (2), we only present the results for *int* and *uni*. When the observed patterns are not comparable, we present more detailed results.

In the international action scenarios, global fossil energy demand is reduced due to more ambitious global climate action. As a consequence, the prices of fossil fuels as well as electricity (which uses fossil fuels as inputs) are reduced. For example, the global oil price is reduced by 3 to 4% in *int* compared to *uni*, the global gas price by 5%, the electricity price in France by 0.5%, the electricity price in Germany by 3.3%. In countries with a high share of coal in the electricity mix, e.g. Germany or Poland, the coal price decreases by approximately 10% in *int* compared to *uni*, whereas, in the other countries, the change is small or negligible (e.g. negligible changes in France).

The impact of these changes in energy prices on the European industrial sectors depends on the electricity and energy intensities of the latter. These are presented for all the model sectors in Figure 1 and Figure 2. Most energy intensive sectors are covered by the ETS:

- Refined oil and coal products,

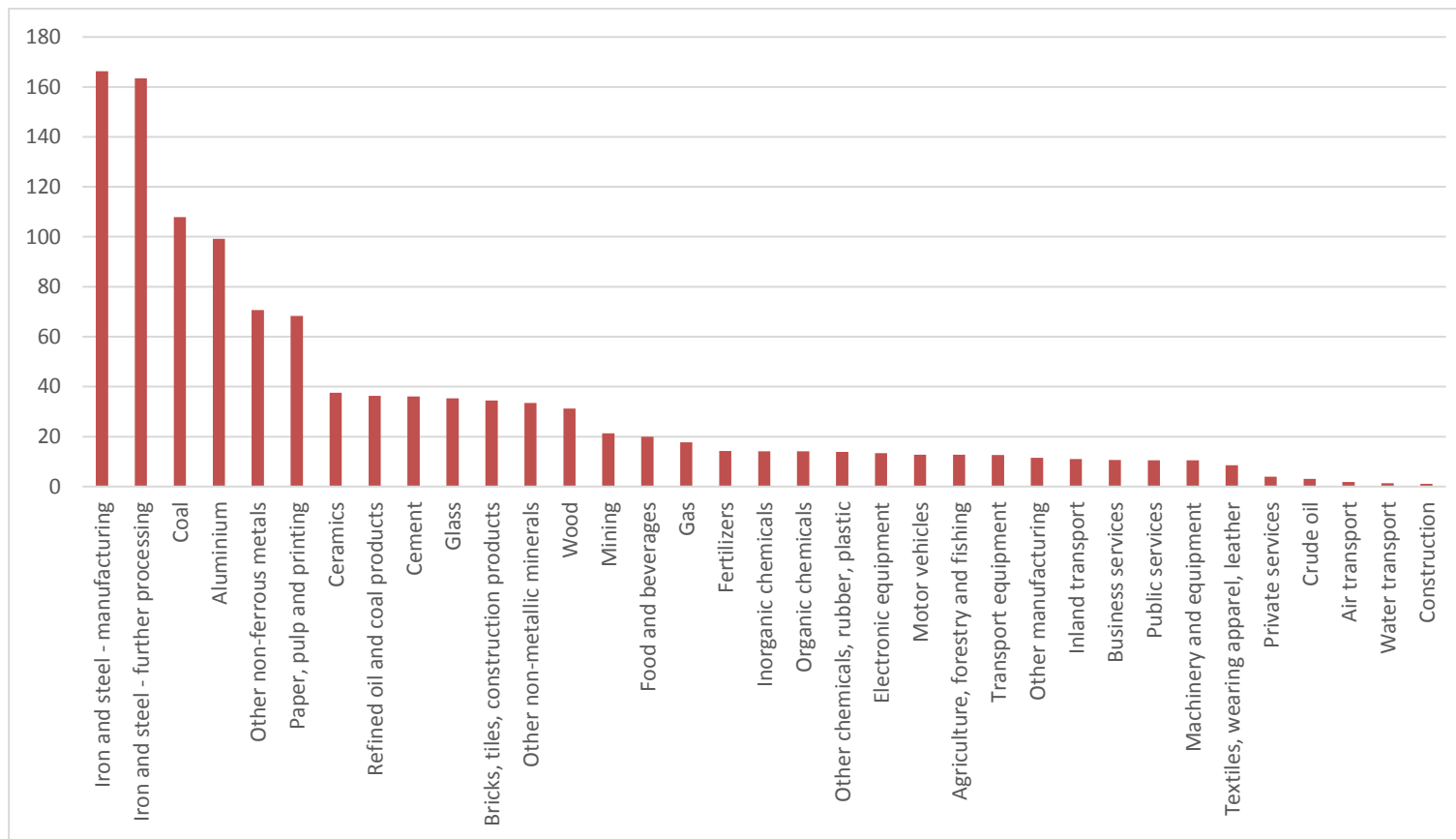
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<sup>38</sup> The United States, South Africa and Brazil present their NDCs for 2025. Whereas for Brazil we can use the indicative target for 2030, we interpolate linearly for the US and South Africa between 2025 and a potential 2050 target. We thereby assume that the US should achieve an 80% GHG reduction vs. 1990 by 2050 and that South Africa should drive their emissions back to the 1990 level.



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- Paper, pulp and printing,
- Fertilizers,
- Organic chemicals,
- Inorganic chemicals,
- Other chemicals, rubber and plastics,
- Cement,
- Bricks, tiles and construction products,
- Glass,
- Ceramics,
- Other non-metallic minerals,
- Manufacturing of iron and steel,
- Further processing of iron and steel,
- Aluminium,
- Other non-ferrous metals,
- Electricity,
- Air transport,
- Crude oil.



**Figure 1:** Electricity intensity of model sectors (toe/M€) for the baseline scenario in 2010

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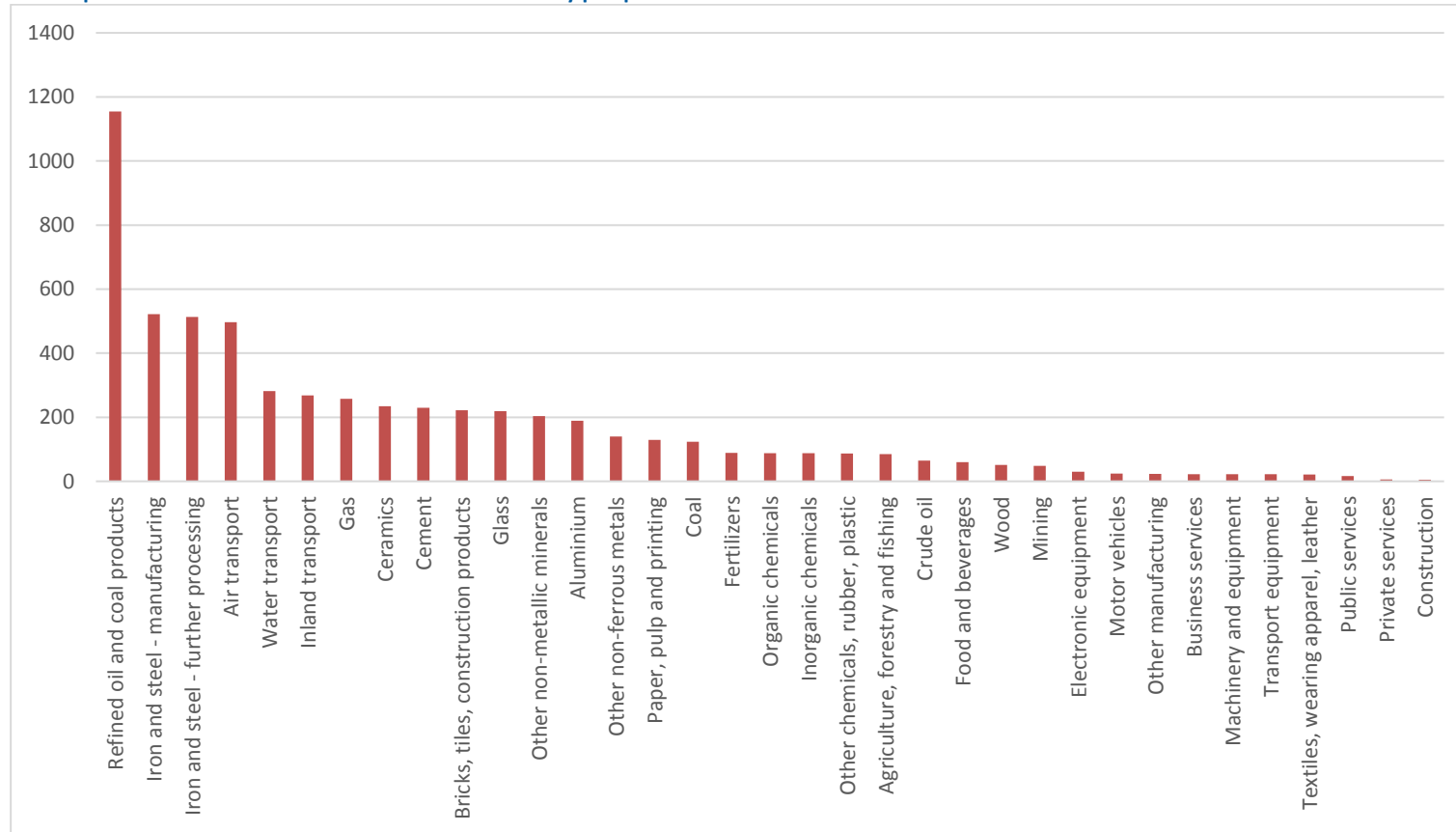
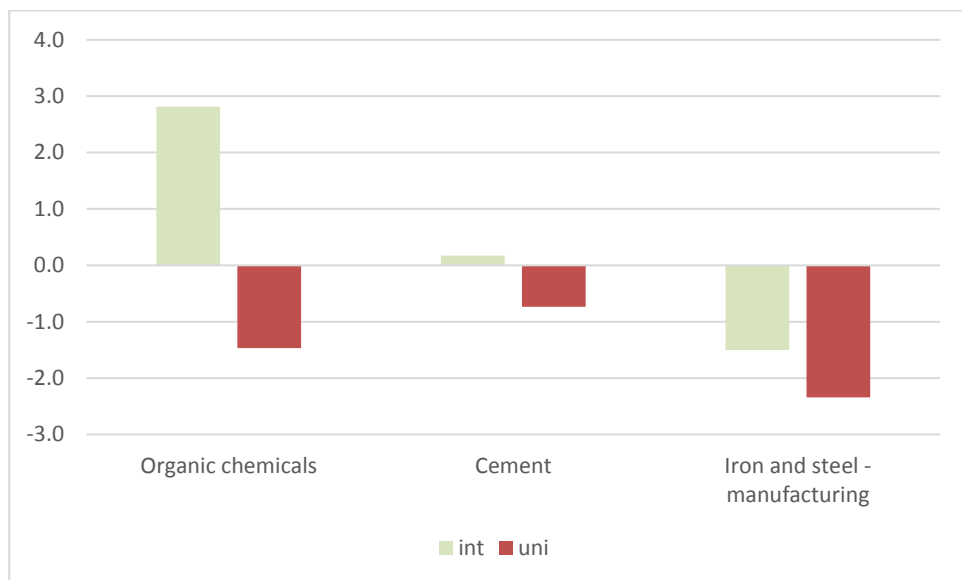


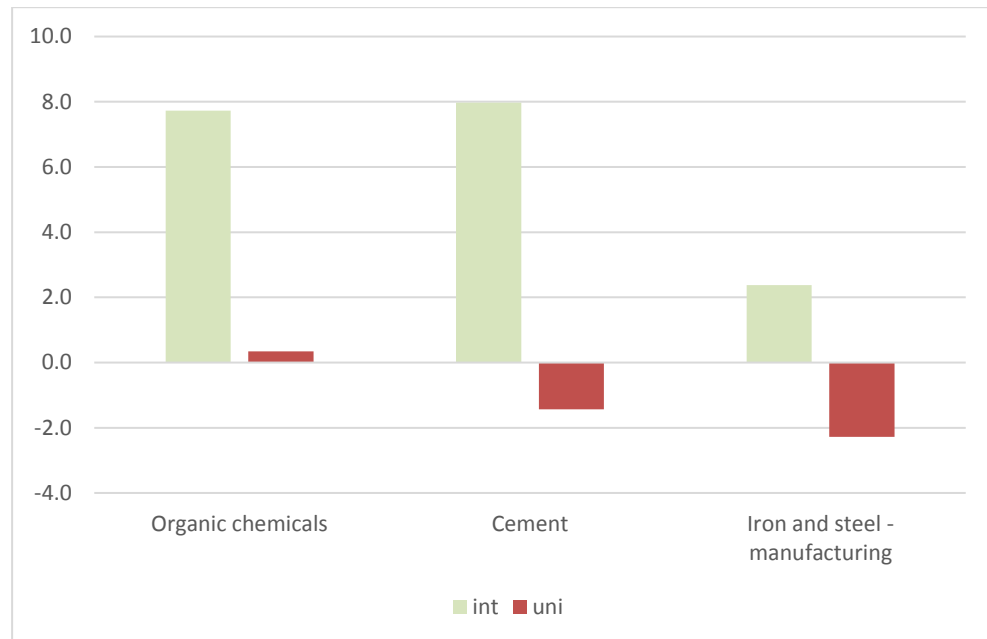
Figure 2: Energy intensity of model sectors (toe/M€) for the baseline scenario in 2010

The sectoral impact of international action depends on at least two mechanisms. On the one hand, sectors that consume energy should be better off due to lower global energy prices and a reduction in the carbon constraint differential between EU and non EU regions (which should induce a gain in competitiveness for EU sectors). On the other hand, more ambitious global climate action results in a reduction in global demand, and hence a decrease in the demand for EU products from non-EU regions.

For energy-intensive ETS sectors, the first effect dominates: these sectors benefit from reduced energy prices. Their output increase as well as their export intensity, defined as unit of export per unit of production, as can be seen for three selected sectors, namely *Organic Chemicals*, *Cement* and *Iron and steel manufacturing*, in Figure 3 and Figure 4.



**Figure 3:** Changes in output of selected sectors in 2030 (% change vs. baseline)

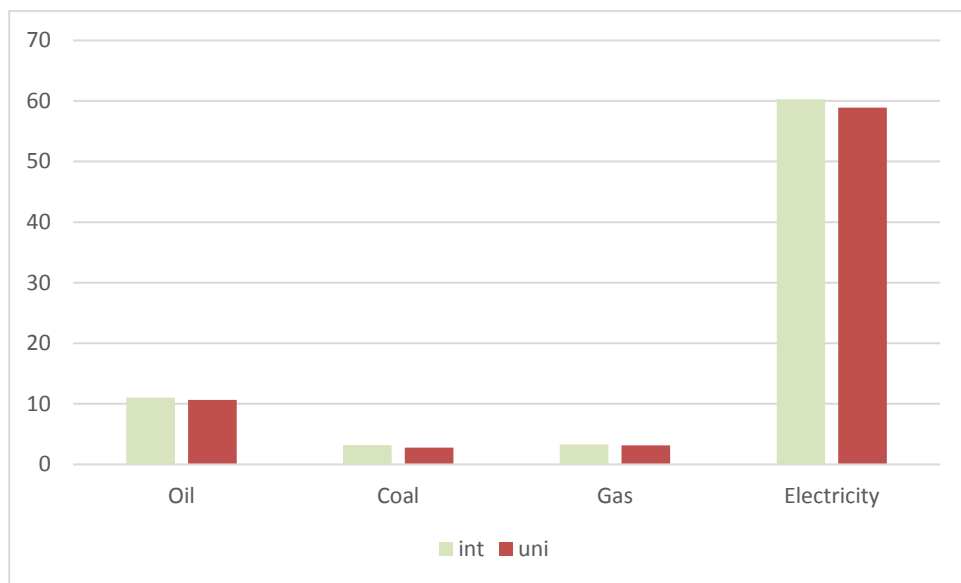


**Figure 4:** Changes in export intensity of selected sectors (% change vs. baseline)

As a consequence, as presented in Figure 5, electricity and fossil fuel demand of the ETS sectors rise in *int* compared to *uni* (3.6% for oil, 15% for coal, 4% for gas, 2.3% for electricity; all these figures refer to the demand of the ETS sectors except electricity), which results in a 9.2% higher ETS carbon price in *int* than in *uni*.

In terms of competitiveness, all EU ETS sectors, except electricity, gain market shares in the *int* scenario compared to *uni*, as can be observed in

Table 16. The reason is that production of electricity in the rest of the world increases due to the tighter global carbon constraint. Electricity differs from the other sectors due to its low export and import intensities. The reduction in electricity price in the *int* scenario impacts the revenues<sup>39</sup> from this sector as can be seen in Table 28 in Appendix 8.3.



**Figure 5:** Demand of ETS sectors except electricity for energy carriers in 2030 (mtoe)

Among the non-ETS sectors, those that are relatively energy intensive, such as *Inland transport* (output and export intensity in Figure 6), benefit from international action in the same way as ETS sectors do.

On the contrary, for the other non-ETS sectors, such as the manufacturing industries, the second effect dominates: the reduction in global demand results in a decrease in output and export intensity. Examples of *Machinery*

<sup>39</sup> Electricity sector revenues depends on the electricity price and on the quantity of electricity sold.

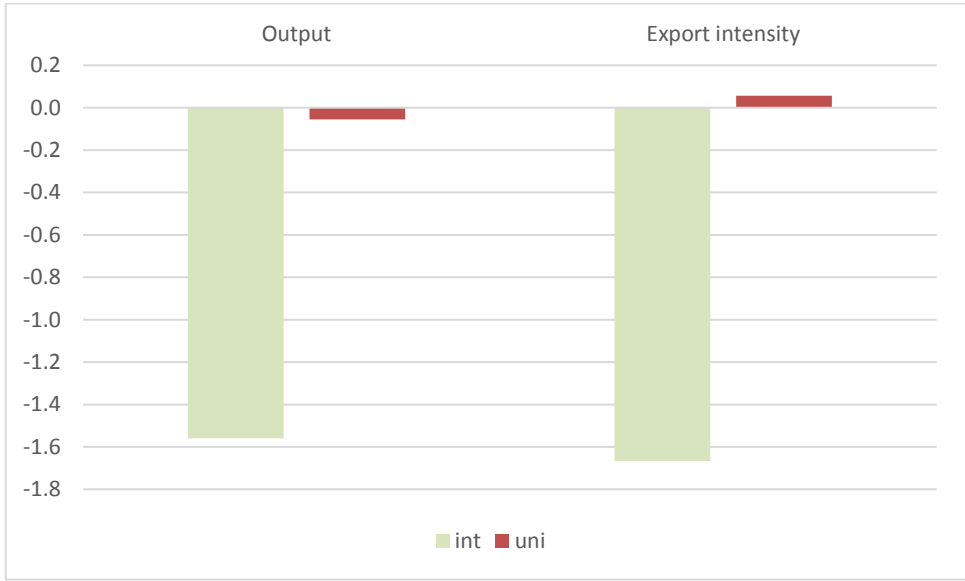
*and equipment* and *Food and beverages*<sup>40</sup> are presented in Figure 7 and Figure 8. The stronger effect for *Machinery and equipment* than for *Food and beverages* can be related to the lower energy intensity of the former compared to the latter.

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<sup>40</sup> In this modeling exercise, *Food and beverage* is not an ETS sector. In reality, some industrial installations of this sector are covered by the scheme. We do not take account of this level of detail in this study.

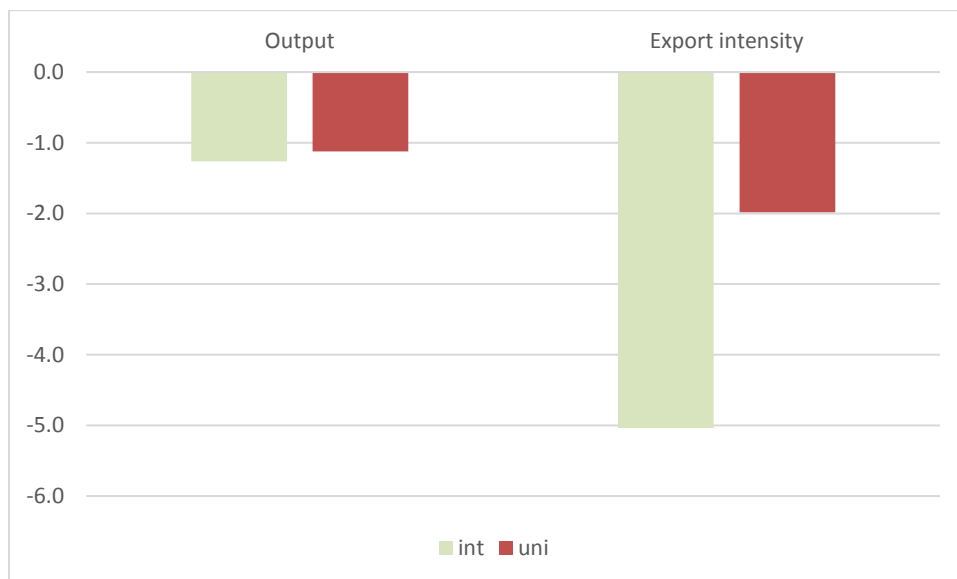


**Figure 6:** Changes in output and export intensity of the sector Inland transport in 2030 (% change vs. baseline)<sup>41</sup>



**Figure 7:** Changes in output and export intensity of the sector Machinery and equipment (% change vs. baseline)





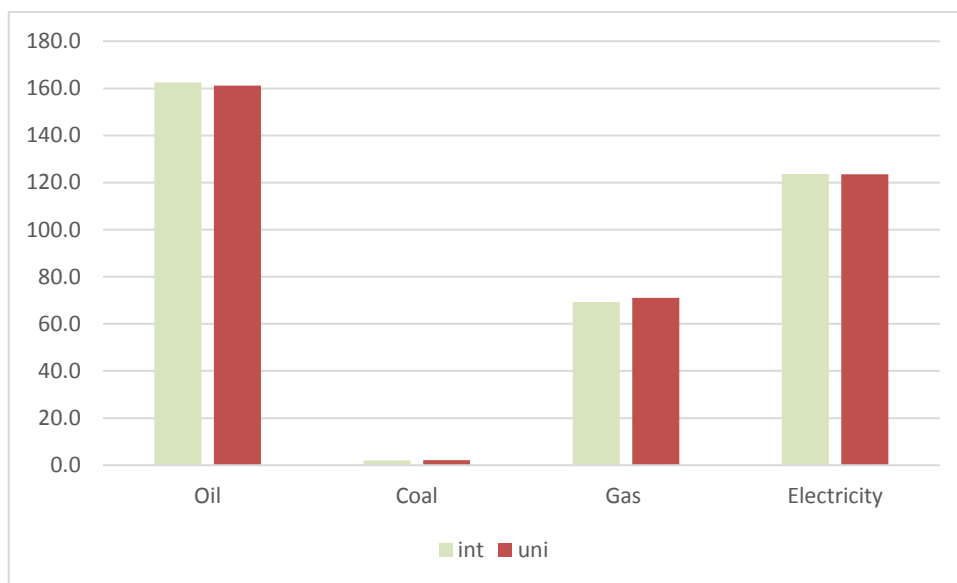
**Figure 8:** Changes in output and export intensity of the sector Food and beverages in 2030 (% change vs. baseline)

In aggregate, in the case of international action, the total demand for coal and gas of the non-ETS sectors is slightly reduced (by 5% and 2.5% respectively), compared to the situation of unilateral action, and slightly increased for oil and electricity (by 0.9% and 0.1%, respectively) (cf. Figure 9). In the model, oil represents two thirds of fossil fuel demand in non-ETS sectors; two thirds of this oil demand comes from *Inland transport*. The consequence is that the non-ETS carbon price rises by around 13% in case of international action compared to unilateral action.

In aggregate for the EU, as shown in the macroeconomic results table, the impact of international action on GDP is positive (in relative terms) compared to the one of unilateral action: -0.7% in *int* compared to -0.9% in *uni*. Households also benefit from international action: in all variations of the *uni* scenarios, households consumption decreases by approximately 0.3%

<sup>41</sup> Exports in the sector “inland transport” includes mainly services from transport companies abroad. In contrast to air and water transport, the absolute value is relatively low.

compared to the baseline level whereas in all *int* scenario variants consumption increases by approximately 0.1% compared to the baseline. This suggests that the positive impact of reduced energy prices on ETS sectors and transport sectors that are not covered by the ETS compensates the negative impact of a reduced global demand on the rest of the economy.



**Figure 9:** Demand of non-ETS sectors for energy carriers in 2030 (mtoe)

Similarly most Member States benefit from international action and see their GDP rise as a consequence of international action: 0.26% increase in *int* compared to *uni* for Spain as well as the regions Rest of Eastern Member States and Rest of Western Member States up to nearly 0.4% for Poland.<sup>42</sup> Only the United Kingdom is slightly worse off when international action is taken (0.1% GDP loss between *int* and *uni*). As an exporter of oil the UK suffers from a declining demand from non-EU countries once they pursue a stricter climate policy.

<sup>42</sup> Poland is affected the least severely and even exhibits gains in scenario *int*. The results for Poland are due to the less stringent targets for RES use in this modelling exercise. We refer to Table 9 for the exact RES target assumed in this study.

#### 4.2.2 Impact of recycling ETS auction revenues to support electricity generation from renewable energy

In this section, we examine the impact of using ETS auction revenues to subsidize power generation from renewable energy. To do so, we compare the *int* and *int\_ren* scenario or *uni* and *uni\_ren* and their variants (1) and (2). As in the previous section, we report the results for all scenarios when the pattern is different between the main scenarios and the variants. If the pattern is the same, we only present a selected set of scenarios.

A first observation from Table 14, Table 15 and Table 16 is that the impacts of this recycling option are significantly smaller than the international action effects analysed in the previous section.

When ETS auction revenues are recycled to support renewable electricity, at least three mechanisms can take place. First, households do not receive the auction revenues as lump-sum transfer any more as they do in *int* or *uni* scenarios. This should result in a reduction of their aggregate consumption (income effect). Second, when auction revenues are directly used to support electricity generation from renewable energy, the electricity levy that households have to pay for their electricity consumption to support power generation from RES is reduced. This results in a positive income effect that partly balances the negative income effect mentioned previously. Third, we expect the reduction in the electricity levy to induce a rise in the electricity consumption by households (price effect). In parallel and similarly, industries that have to pay the electricity levy should also increase their electricity consumption when auctions revenues are used to support power generation from RES.

What we observe is indeed a rise in electricity demand in the whole economy, as one can see in the macroeconomic results table (Table 14): 3.1% change in *int* compared to the baseline scenario, 4.4% in *int\_ren*. This directly explains the higher ETS price in the scenarios with the renewable subsidy: 1.3% increase in the *int\_ren* compared to *int*, 0.8% increase in *uni\_ren* compared to *uni*.

If we examine the impact of this auctions revenues recycling option on the ETS sectors, we see that the impact on output depends on the exemption rules (see Figure 10 for three selected sectors). If they have to pay the electricity levy (variant (2) of the scenarios), they are better off when auction revenues are used to subsidize power generation from RES. They then use more electricity as well as more fossil fuel (income effect).

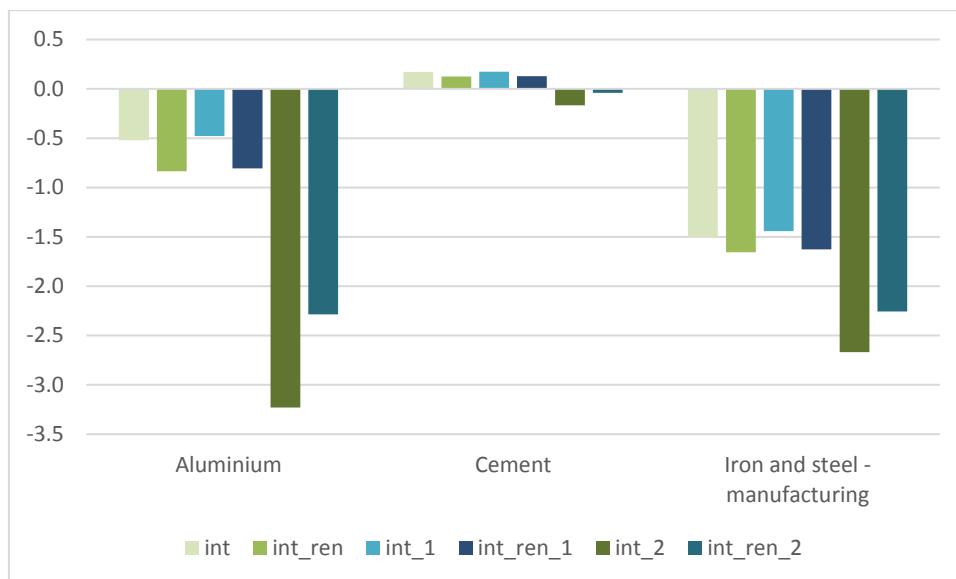
If the ETS sectors are exempted (main scenarios and variant (1)), the use of auction revenues to subsidize renewable electricity generation make them worse off.<sup>43</sup> The reason is that, despite the subsidy to RES electricity, the increased electricity demand in the whole economy results in a slight increase in the price of electricity in some countries (for example 3% in France in the scenarios with the subsidy compared to the scenarios without). By substitution effect, the ETS sectors tend to use slightly more fossil fuel.

A striking observation is that ETS sectors are better off when they are exempted from the electricity levy: their output is clearly smaller in *int\_2* and *int\_ren2* than in the other scenarios. However combining exemptions for these sectors and auctions revenues recycling to RES support is not the most beneficial to energy-intensive sectors: with such a recycling option, all consumers benefit from the reduced levy, overall electricity demand rises, inducing a negative impact on energy intensive industry. This suggests that targeted exemptions are more effective than more general policy (i.e. general reduction of the electricity levy) if the objective is to maintain the activity level of some specific sectors.<sup>44</sup>

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<sup>43</sup> For organic chemicals, we note that the changes are minor and even positive. The reason for this might be the fact that, among the ETS sectors, it is one of the less energy intensive ones.

<sup>44</sup> We also observe this when analyzing the impact of free allocation for trade exposed sectors (benchmarking) compared to full auctioning. This has not been examined in this specific report but in previous studies.



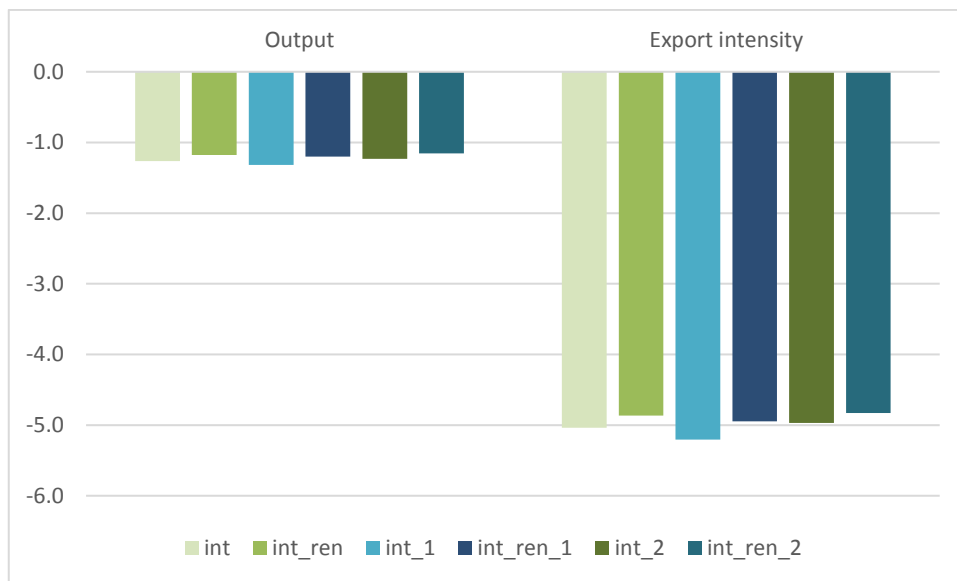
**Figure 10:** Changes in output of selected sectors in 2030 (% change vs. baseline)

In terms of competitiveness, the auction revenues recycling option seems to have no significant impact on the world market shares of the EU ETS sectors, except for electricity, which is obviously better off when benefiting from the subsidy. This is consistent with the observation that the impacts of this recycling option are relatively small compared to the international action effects analysed in the previous section.

From the perspective of the energy intensive sectors, the combination of an electricity levy and exemptions, without auctions revenues recycling to RES seems to lead to the best outcomes. However, the impact on the non-ETS sectors and on households need to be taken into account.

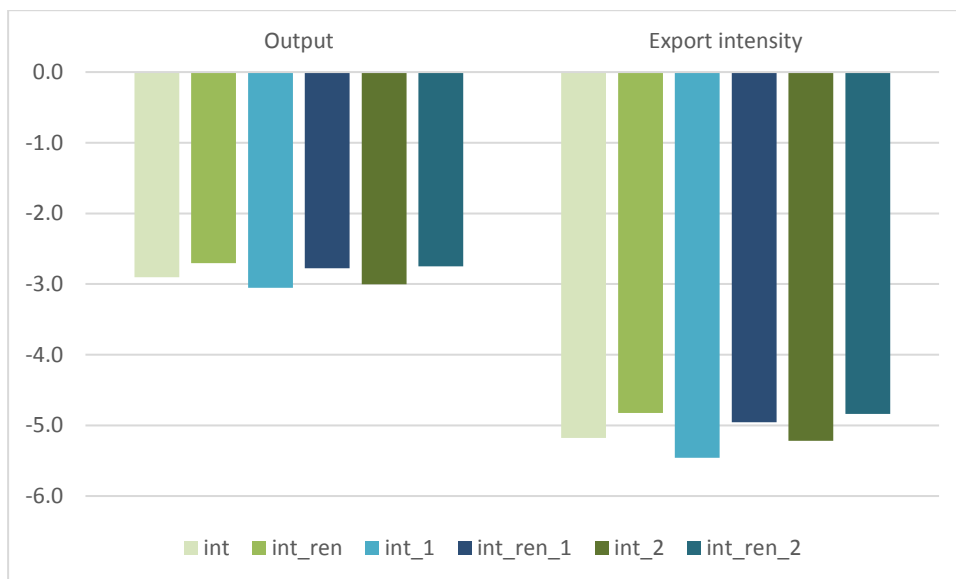
For the non-ETS sectors, at least two effects can take place. On the one hand, using auction revenues to subsidize RES electricity generation should make the non-ETS sectors better off because the electricity levy they have to pay is reduced. On the other hand, they can be disadvantaged by a possible increase in the energy prices (small electricity price increase due to a larger demand from the whole economy, small price increase for some fossil fuels due to slightly increased demand from ETS sectors). The final effect is a balance of the two.

For example the *Food and beverage* sector, which is relatively electricity-intensive relative to the other non-ETS sectors (cf. Figure 1), benefits as shown in Figure 11 below. For the manufacturing sectors on the contrary, the impact is minor (less than 0.1% change in output or export intensity in *int\_ren* compared to *int*).



**Figure 11:** Changes in output and export intensity of the sector Food and beverages in 2030 (% change vs. baseline)

*Inland Transport* benefits from this recycling option (cf. Figure 12Figure 6) due to a demand effect from the non-ETS sectors that have to pay the electricity levy and are better off when the latter is reduced.



**Figure 12:** Changes in output and export intensity of the sector Inland transport in 2030 (% change vs. baseline)

In terms of competitiveness, we observe no significant impact of this recycling option on the non-ETS sectors world market shares.

In aggregate, despite the fact that the activity of some non-ETS sectors is higher when auctions revenues are used to support renewable electricity, the non-ETS carbon price is smaller (4% reduction in *int\_ren* compared to *int*). We suggest that the reduced electricity levy allows these sectors to make use of cheaper abatement opportunities, in particular through a larger use of electricity (2.3% change in *int\_ren* compared to *int*).

In aggregate for the whole economy, the positive GDP change is driven by the increased output in some non-ETS sectors. Those are not exempted from the levy, but they have a significant use of electricity and benefit from recycling auction revenues to support RES electricity.

The quantitative impact of this revenue recycling option on households is negligible. In the scenarios in which auctions revenues are used to support RES, households do not receive these revenues as a lump sum but they benefit from the increased economic activity in the EU. These two effects seem to balance one another.

## 5 Discussion of the Modelling Results

To our knowledge, this is the first study that examines the sectoral impact of using ETS auction revenues to support power generation from renewable energy in a model that allows taking into account international climate action.

In the stylized scenario used here, the effects of this auction revenues recycling option are relatively small compared to the effect of international climate action.

While, in aggregate, the EU economy benefits from international action, some sectors are negatively impacted. Whereas most ETS sectors gain in competitiveness in the case of international action, the electricity sector suffers from a reduced electricity price. For the non-ETS sectors, the advantage of reduced energy prices is limited by a reduction in global demand. In the end, some of these sectors, such as the manufacturing industries lose some world market shares.

The effect of using carbon auction revenues to subsidize power generation from renewable sources depends on the electricity levy simulated in the model to support national RES targets in the power sector and on the potential associated exemption rules. While, at the aggregate level, the EU benefits from this recycling option (GDP increase), the sectoral impact varies. If ETS sectors have to pay the electricity levy, they are better off when a renewable subsidy is used. But if they are exempted from this levy, the use of auctions revenues to subsidize renewable electricity generation make them worse off. The effect of this revenue recycling option on households' consumption is negligible. Whereas they directly receive the auctions revenues in case of a lump sum transfer, they benefit from the increased economic activity in case of renewable electricity support. In terms of competitiveness, this auction revenue recycling option seems to have no significant impact on the world market shares of the EU ETS sectors, except for electricity, which benefits from the subsidy. For the non-ETS sectors, while the renewable subsidy is often, but not always, beneficial in terms of output, the impact on the world market shares is not significant.



For all scenarios, we observe that losses in sectoral output nearly ever induce losses in competitiveness, even in the case of unilateral EU climate action. The reason is that the changes in the world market share also depend on the economic outputs in the rest of the world.

While this analysis provides some insights on the competitiveness impact of the specific climate and energy policies examined here, it is important to keep in mind that the scenarios are relatively stylised and that they rely on some assumptions.

First, emissions from greenhouse gases other than carbon are not included in the model; this could have a significant impact on agriculture and, by general equilibrium effect, on its related demand and supply sectors.

Second, specific national policies are not represented in detail. The results observed here could be altered by taking better account of the sectoral policies used by Member States to reach their respective targets in the non-ETS sectors.

Third, the bottom-up module included in the model to represent the various electricity generation technologies is only included for the EU model regions. In particular, renewable energy sources are only represented for EU regions, which means that for non-EU regions, this study only considers CO<sub>2</sub> reduction policies. This could have an impact on the GDP of these regions and, by general equilibrium effect, on the EU sectors particularly exposed to international trade.

Finally, PACE does not include potential benefits from the climate change impacts and air pollution costs which are avoided, something which, for instance, integrated assessment models do. An inclusion of such issues may result in additional gains in some indicators.

## 6 Conclusions

The present study evaluates the impact of the 2030 Framework for climate and energy policy on the competitiveness of the EU industry using different stylised policy scenarios. The analysis focuses more specifically on two different levels of international action within the Paris agreement (international versus unilateral action beyond 2020) and two different auction revenue recycling options (lump-sum transfer to households or subsidy to electricity production from renewable energy).

In the scenarios analysed, the impact of international action compared to unilateral action is larger than the effect of the auction revenue recycling option. In particular, while international action clearly has implications for the world market shares of European economic sectors, the second does not cause significant changes in this regard.

In the case of international action, fossil fuel and electricity prices are reduced as a consequence of the more ambitious global climate policy. While the revenues for the electricity sectors suffer from this, all other ETS sectors, which are energy intensive, benefit, both in terms of output and world market shares. In aggregate the larger demand for fossil fuel and electricity of the ETS sectors causes the ETS carbon price to rise. Among non-ETS sectors, those, such as *Inland transport*, that are relatively more energy intensive similarly benefit from the reduced energy prices. On the contrary, the other sectors are disadvantaged by the reduction in global demand due to the more stringent climate constraint. Their output is reduced. For the most energy intensive of these non-ETS sectors, this does not really impact their world market shares, while for the others, including the manufacturing industries, it causes a loss. The non-ETS carbon price rises mostly due to an increased activity of the transport sector and the associated oil demand. In aggregate for the EU, the GDP impact of international action is positive compared to unilateral action: -0.7% in *int* compared to -0.9% in *uni*. The positive impact of reduced energy prices on ETS sectors and other relatively energy intensive sectors compensates the negative impact of a reduced global demand on the rest of the economy.

Using ETS auctions revenues to support electricity generation from renewable sources results in a rise in electricity demand in the whole economy (3.1% change in *int* compared to the baseline scenario, 4.4% in *int\_ren*) due to the reduced electricity levy that electricity consumers have to pay to support the renewable energy in the power sector. As a consequence the ETS carbon price increases: 1.3% increase in the *int\_ren* compared to *int*, 0.8% increase in *uni\_ren* compared to *uni*. For the ETS sectors other than electricity, the impact depends on the exemption rules. If they have to pay the electricity levy, they are better off when auctions revenues are used to subsidize power generation from RES. They then use more energy (electricity and fossil fuel). If the ETS sectors are exempted, the use of auctions revenues to subsidize renewable electricity generation make them worse off, due to a slightly higher electricity price induced by the increased electricity demand in the rest of the economy. However, in terms of competitiveness, we observe no significant impact of this recycling option on the world market shares of the EU ETS sectors, except for electricity, which gains as it benefits from the subsidy. This is explained by the fact that the changes in the world market shares also depend on the economic outputs in the rest of the world.

For the non-ETS sectors, the effect varies. Sectors such as *Food and beverage* that are relatively electricity-intensive relative to the other non-ETS sectors see their output rise as consequence of this auctions revenue recycling. In other sectors, such as the manufacturing industries, the impact is hardly visible. *Inland Transport* benefits from this recycling option due to a demand effect from the non-ETS sectors, which have to pay the electricity levy and are better off when the latter is reduced. In terms of competitiveness, we observe no significant impact of this recycling option on the world market shares of these non-ETS sectors.

In aggregate for the whole economy, this auction revenue recycling option induces a gain in GDP. The non-ETS carbon price is reduced as a consequence of the possibility for the non-ETS sectors to use cheaper abatement opportunities, including through a larger use of electricity.

This analysis provides some interesting insights on the impact of specific climate and energy policies in the context of an evolving international climate action context. Some underlying assumptions need to be kept in mind in order to use the results with care, for example the absence of greenhouse gases other than CO<sub>2</sub> in the model or the simplified representation of national policies. This work could be complemented by further development of some of these features. For instance, future analyses of this type would benefit from extending the representation of the electricity sector to non-EU regions or including land-use emissions in the model.



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## 8 Appendix

### 8.1 Detailed Model Description

PACE is implemented in MPSGE (Mathematical Programming System for General Equilibrium Analysis; Rutherford, 1999), a subsystem of GAMS (General Algebraic Modeling System; Brooke et al. 2010), using PATH (Dirkse and Ferris 1995) for solving the MCP (mixed complementarity problem). The model can run until 2050 in five-year time steps and solves for a sequence of market equilibria. The model consists of a set of equations (viz. market clearing, zero profit, and income balance conditions) that describe the world economy. For each year, the solution algorithm finds the set of prices and quantities that solves these equations.

Zero-profit conditions and market clearing conditions follow directly from the assumptions of profit maximization of firms, perfect competition among them, utility maximization of consumers, constant returns to scale in production, and homothecy of consumer preferences. The latter class of conditions determines the price of each output good as the unit cost to produce this good. This cost equals the marginal and (given constant returns to scale) the average cost of production. Crucially, the zero profit assumption entails that firms cannot pass on the expenses for emission permits to consumers if those are refunded to them under a free allocation scheme.

Each region consists of a representative consumer and representative producers (one for each production sector). The consumer chooses a bundle of consumption goods that maximizes her utility given her preferences and her budget. The budget is determined by her income received from selling the primary production factors (labour, capital and fossil-fuels) that she owns. The model also assumes that each region can obtain a certain amount of emission permits in each period. Final demand of the representative consumer is modelled as a constant elasticity of substitution (CES) composite good which combines an energy aggregate with a non-energy aggregate (analogue to the production structure described below).

Substitution patterns within the non-energy aggregate are reflected by a Cobb-Douglas function. The energy aggregate consists of several energy goods combined with a constant elasticity of substitution.

The producers choose bundles of production goods that maximize their profits given their production possibilities. The production possibilities are determined by technologies, which efficiently transfer certain amounts of input goods and production factors into certain amounts of unique, sector specific output goods. Production factors entail labour, capital, (both perfectly mobile between sectors within a region) and sector specific resources for agriculture, oil and gas extraction, and coal and other mining. The labour supply is fixed for each region. There is full mobility among sectors and no unemployment. The production functions are nested CES functions with the following nesting structure: At the top level, non-energy inputs are employed with an aggregate of energy, capital and labour. At the second level, a CES function describes the substitution possibilities between the energy aggregate and the aggregate of labour and capital. At the third level, capital and labour (and if applicable: sector specific resources) are combined with a constant elasticity of substitution. Moreover, at the third level, the energy aggregate consists of electricity and a fossil fuel input. The latter input is further split into coal, gas and oil associated with different elasticities of substitution and with emission permits in fixed proportions (in the presence of a carbon pricing scheme). The CES specification allows producers to substitute fossil fuel inputs by other inputs as a reaction to an increasing carbon price. The extent of substitution, however, is limited by the choice of the cost minimizing input bundle given the elasticities of substitution. Moreover, each good used in intermediate and final demand corresponds to a CES aggregate of a domestically produced variety and a CES import aggregate of the same variety imported from the other regions (Armington, 1969).

The electricity sector is modelled in a bottom-up module. It is still a general equilibrium representation based on CES production functions, however much more disaggregated for different technology types. Hence, technology specific capital is represented in this module. The model distinguishes

different power generation technologies, namely coal, refined oil, gas, nuclear and a renewable energy aggregate. Just like other sectors, power generation can substitute fossil fuel consumption with other inputs in order to mitigate emissions.

The tax system includes production taxes and subsidies, intermediate good taxes, input factor taxes, consumption taxes as well as tariffs. The government collects tax revenues and redistributes them to the representative consumer in a lump-sum way. The use of fossil energy in production requires producers to pay for the released carbon corresponding to the physical carbon content of each fossil fuel input in the presence of a carbon pricing scheme and of auctioning allowances. In case of free allocation of allowances (for example in combination with a benchmarking scheme), producers have to pay for carbon inputs in the same way in the first step. In the second step, producers receive a subsidy which compensates them for the bill paid in the first step (compare Jensen and Rasmussen, 2000; Edwards and Hutton, 2001). As a result of this subsidy, the producer expands output which raises the demand for fossil and other inputs. Under a cap for allowances, this will in turn drive up the carbon price. In this study, we assume that free allocation is based on actual output. Therefore, we do not consider grandfathering (which is based on reference emissions) but “complete” free allocation of emission allowances, i.e. in the model free allocation is treated as a dynamic allocation. The model allows for free trading of allowances without transaction costs across sectors within the EU emissions trading scheme (EU ETS). Sectors outside the ETS need to reduce emissions, too, so that the total emissions target of the EU is met. This is achieved by setting country specific carbon taxes that are chosen by the model such that the country specific emission reduction targets are met. They are determined such that the ratio between issued ETS permits and non-ETS emissions is kept at the level given by the baseline scenario.<sup>45</sup> This assumption leads to a CO<sub>2</sub> emissions reduction in ETS and non-ETS sectors

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<sup>45</sup> To be more precise, this ratio is used as a starting value for the model to solve. Slight deviations from that ratio are hence possible.

close to that foreseen in the Impact Assessment of the 2030 Framework: 43% in ETS sectors vs. the 2005 level and 30% in non-ETS sectors vs. the 2005 level. These country specific carbon taxes are recycled in the same fashion as ETS revenues, i.e. as a lump sum transfer to the representative consumer. They represent national CO<sub>2</sub> shadow prices of the non-ETS sectors. Importantly, the model does not take any impacts due to climate change into account. Such impacts would include reduced productivity due to yield losses in agriculture, heat stress, and diseases, but might also be positive in some regions. They would also include destruction of capital due to flooding at coasts and large rivers, due to storms and avalanches, and other disasters. The avoidance of these overall costs of climate change creates a benefit that is not captured in the model. In our scenario analysis, different policy scenarios will result in different global emissions and thus regional climate damages, which are not included in our numerical policy valuation.

## **8.2 Detailed Description of Data and Baseline Calibration**

Calibration of CGE models requires a balanced social accounting matrix (SAM) so that transactions between sectors and the representative agent and government can inform the production functions of sectors and utility function of agents. Production and utility functions are calibrated such that cost-minimizing firms and utility maximizing agents make exactly the choices that lead to the transactions represented by the SAM. In the context of climate change policy, due to the necessity of measuring emissions in terms of physical units rather than value flows, the SAM has to be complemented by quantitative information about the energy and fuel consumption of the sectors and agents which corresponds to the SAM's value flows. In addition to this calibration to a benchmark year of the world economy, assumptions about future growth patterns of regional GDP on the one hand and sectoral energy use on the other are crucial to a multi-period analysis of climate policy. Growth of GDP can be induced by letting the availability of the production factors increase by the corresponding rates for each region. The model, assuming production and utility functions as in the base year, will then endogenously balance trade imbalances caused by asymmetric growth of regions. To reproduce assumptions about changes in energy intensity of

economic activities, however, the production functions themselves have to be changed. Again, changes to the production function are introduced (e.g. the share of energy needed to produce a given amount of output is decreased and other inputs increased) and the model is endogenously rebalanced. This chapter describes in more detail the data this calibration process was based on for the PACE model.

The first time period modelled by the PACE model is 2010, and the model then proceeds in steps of five years. The starting period 2010 is calibrated using interpolated data for 2011 from the GTAP 9 data base (Global Trade Analysis Project; Badri and Walmsley, 2008).

GTAP 9 provides information for the base years 2004, 2007 and 2011. This study uses data for the base year 2011 for model calibration.

Within the European Union we distinguish the five largest economies as well as Poland as separate regions. The remaining EU countries are gathered in two groups: “Rest of Western MS” and “Rest of Eastern Member States”.

Regarding the sectoral coverage, the most recent model version distinguishes 36 production sectors that include nine disaggregated energy intensive sectors (Fertilizers and other nitrogen compounds; Organic chemicals; Inorganic chemicals; Cement; Bricks, tiles and construction products; Glass; Ceramics; Manufacturing of iron and steel; and Aluminium)<sup>46</sup> beyond the sectors in the GTAP 9 data base as an extended feature based on Löschel et al. (2009).

The additional energy intensive sectors are added to the GTAP 9 database by means of the Splitcom routines (Horridge, 2005). Based on additionally collected data from diverse sources, Splitcom disaggregates all relevant values of the underlying GTAP 9 database – such as production, trade, primary and intermediate inputs and final use – at the sectoral level for all model regions and balances the extended GTAP 9 database with the newly

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<sup>46</sup> Other non-ferrous metals, Other non-metallic minerals, Further processing of iron and steel and Paper, pulp and printing are other energy intensive sectors.

added sectors. The sector split is performed by using information on the relative size of the disaggregated sectors in production, international trade, energy consumption (electricity and fuel use) and final consumption.<sup>47</sup>

The main data source for the disaggregation is EXIOPOL (2011) and additional sources are Eurostat (2011)<sup>48</sup> and UN (2011a, b).

Elasticities of substitution in international trade (so-called Armington elasticities) are based on empirical estimates reported in the GTAP database. Certain CES elasticities of substitution between production factors (capital, labour, energy inputs, and non-energy inputs) are taken from Okagawa and Ban (2008) based on recent sectoral panel data estimates for the period 1995 to 2004.<sup>49</sup> A higher value of the Armington elasticity denotes a better possibility to substitute inputs for each other due to price changes. An elasticity value of zero denotes a Leontief relationship without substitution possibilities; this means all inputs are used in fixed proportions.

Data for the future economic development are taken from the International Energy Outlook of the US Department of Energy (IEO 2013) for the **non-EU regions**. The 2013 IEO provides detailed regional data on total and fuel-specific primary energy consumption and carbon emissions given assumptions on the development of GDP, fossil fuel prices and other factors. The data take population growth and (exogenous) technical progress into account.<sup>50</sup> Moreover, the 2013 IEO offers several additional baselines which will be described further below.

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<sup>47</sup> For detailed information on the sectoral disaggregation, cf. Alexeeva-Talebi et al. (2012).

<sup>48</sup> Eurostat Structural Business Statistics (SBS) for production values and purchases of energy products, and Eurostat External Trade for import and export values.

<sup>49</sup> Negative estimates in the original dataset are replaced. – Despite using such estimates, the choice of elasticities – such as the elasticities of substitution in the production function and the elasticities of electricity supply for different energy sources – involves crucial uncertainties in *all* existing numerical models.

<sup>50</sup> Technical progress involves crucial uncertainties in all existing numerical models.

For the **EU regions**, a project specific baseline<sup>51</sup> based on projections from the EU Reference Scenario 2016 was used for calibration. It takes into account national and EU wide policy regulations which have been implemented in the recent years. The results of the policy scenarios are presented for the most part as changes compared to this baseline.

The data used for this baseline are the most recent Reference 2016 projections up to 2050 (in five year time steps) and were provided to DG GROW and the project team by DG CLIMA and DG ENER. For the purpose of calibrating the PACE baseline, Reference 2016 results for production and consumption of primary energy (distinguishing fossil fuel sources, nuclear and numerous renewable energy types), CO<sub>2</sub> emissions, and fuel use for a large number of industrial sectors were used. Furthermore, projections on indicators such as GDP, fuel and CO<sub>2</sub> prices, and electricity generation were incorporated into the PACE baseline.

However, on the sectoral level, the Reference 2016 projections available are not as detailed as the PACE version used for this project. Therefore, Reference 2016 parameters with sectoral detail are disaggregated according to the corresponding shares of each PACE sector within the respective aggregate Reference 2016 sector. In particular, data on energy demand are considerably more detailed in the 2013 IEO and in GTAP than in the available Reference 2016 projections. The former provides the corresponding data in each sector for each fuel type. In the Reference 2016 projections, on the other hand, for most sectors no such detail was available. To combine the advantages of both data sources, we use growth rates of sectoral energy demands from Reference 2016 projections, whereas the fuel mix in each sector is computed according to IEO information. Nevertheless, we decompose the aggregate information on fossil fuel use provided in Reference 2016 using consumption shares from the IEO projections. Only for electricity generation and the fossil fuel sectors does Reference 2016 output

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<sup>51</sup> In the following, we will use the term baseline when referring to the reference baseline. When referring to additional baselines, this will be explicitly stated.



provide details on the fuel mix and in these cases the fuel mix as given by Reference 2016 was used for the baseline calibration.

For some sectors, namely “refineries”, “electricity”, “other transport” (i.e. road and rail transport, auxiliary transport activities) and households, emissions calculated in this manner still deviate to a high extent from emissions as given by Reference 2016. In the latter two cases, we use respective fuel based emissions data from Eurostat. Nevertheless, also the Eurostat data lack detailed information on the source of emissions, i.e. the specific fuels the emissions are based on. This is required to run simulations with PACE. Therefore, to calculate the specific emissions by energy carrier we use respective shares from the environmental accounts of the WIOD (World Input-Output Database)<sup>52</sup>. Overall emissions levels for those sectors as provided by Eurostat remain unaffected by this procedure.

While all other sectors are assumed to burn their fuel input under emission of CO<sub>2</sub>, the refineries sector will not burn all of it but will process a considerable share of fuel input in order to resell them. We thus split fuel inputs between energy use (the sector burns the fuel and produces emissions) and intermediate inputs (the sector modifies the fuel and sells it as output) such that the burned share of the fuels causes the emissions given in GTAP emissions data.

The fact that sectoral fuel use in PACE does not necessarily agree with the fuel mixes implicit to the Reference 2016 results makes for different base year CO<sub>2</sub> emissions from fuel combustion as well as different predictions about future emission trends. To ensure a maximum degree of consistency between the two applied databases, we assume the same relative increase of emissions between 1990 and 2010 as the Reference 2016 projections and thus infer 1990 values from the 2010 PACE base year values. We proceed in the same fashion for the non-EU regions, using the CO<sub>2</sub> emissions index of

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<sup>52</sup> [http://www.wiod.org/new\\_site/database/eas.htm](http://www.wiod.org/new_site/database/eas.htm)

POLES projections which were also provided to DG GROW and the project team by DG CLIMA and DG ENER.

Process emissions were included for all model sectors in all model regions. To this end, we made use of process emissions data from the World Input Output Database (WIOD).<sup>53</sup> The advantage of this database is that the sectors are relatively similar to the PACE sectors and can thus be translated in a relatively straightforward fashion. We calculated the share of process emissions in total emissions. We then included them in the production function using this share. That procedure was chosen since we could use WIOD to obtain process emission for all model sectors. In contrast to fuel based emissions which are tied to the fossil fuel input into each sectoral production function, process emissions are tied to the output of each sector and hence depend on the production level rather than the fossil fuel input level. In terms of the treatment of emissions trading, each ton of process emissions is connected to one EUA certificate, just as fuel based emissions.

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<sup>53</sup> [http://www.wiod.org/new\\_site/home.htm](http://www.wiod.org/new_site/home.htm)

### 8.3 Additional Modelling Results

**Table 17:** Complete results for macroeconomic and environmental indicators for policy scenarios – EU28 aggregate in 2030

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
ETS	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982	0.982
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159.5	173.5	153.7	187.9	165.2	176.8	156.0	182.8	161.0	174.3	153.9
Free allowance share (%)	26.6	26.0	26.6	26.0	26.6	26.0	26.6	26.0	26.6	26.0	26.6	25.9
Cost of policy (change in consumption in trillion 2010 €)	0.011	-0.027	0.011	-0.028	0.013	-0.026	0.012	-0.027	0.012	-0.026	0.012	-0.027
GDP (% change vs. baseline)	-0.7	-0.9	-0.6	-0.9	-0.7	-1.0	-0.6	-0.9	-0.7	-1.0	-0.6	-0.9
CO2 emissions (% change vs. baseline)	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9	-16.9
ETS	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6	-18.6
Energy demand (% change vs. baseline)	-6.5	-8.2	-6.1	-7.9	-7.0	-8.6	-6.3	-8.1	-7.0	-8.6	-6.4	-8.1
Electricity demand (% change vs. baseline)	3.1	2.0	4.4	3.1	1.7	0.9	3.7	2.6	1.3	0.6	3.5	2.5
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.1	-0.3	0.1	-0.3	0.1	-0.3	0.1	-0.3	0.1	-0.3	0.1	-0.3

**Table 18:** Regional macroeconomic and environmental impacts in 2030 – *France*

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.269	0.268	0.269	0.268	0.268	0.267	0.268	0.267	0.269	0.268	0.269	0.268
ETS	0.082	0.080	0.082	0.080	0.082	0.080	0.082	0.080	0.082	0.081	0.082	0.080
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	0.003	-0.003	0.002	-0.002	0.003	-0.002	0.003	-0.002	0.003	-0.002	0.003	-0.002
GDP (% change vs. baseline)	-0.6	-0.9	-0.5	-0.8	-0.7	-1.0	-0.5	-0.8	-0.6	-0.9	-0.5	-0.8
CO2 emissions (% change vs. baseline)	-13.3	-13.7	-13.3	-13.8	-13.6	-13.9	-13.5	-13.9	-13.4	-13.8	-13.3	-13.7
ETS	-7.5	-9.3	-7.6	-9.4	-7.5	-9.3	-7.6	-9.4	-7.3	-9.1	-7.4	-9.2
Energy demand (% change vs. baseline)	-7.3	-8.4	-6.8	-8.0	-7.5	-8.5	-6.9	-8.0	-7.3	-8.4	-6.8	-7.9
Electricity demand (% change vs. baseline)	5.8	5.0	7.4	6.5	6.1	5.2	7.5	6.6	5.9	5.1	7.4	6.6
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.2	-0.2	0.2	-0.2	0.2	-0.2	0.2	-0.2	0.2	-0.2	0.2	-0.2
Electricity price (2010 €/MWh)	110	110	113	114	110	111	113	114	110	110	113	114

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Table 19: Regional macroeconomic and environmental impacts in 2030 – Germany

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.499	0.496	0.497	0.494	0.498	0.495	0.497	0.494	0.499	0.496	0.498	0.495
ETS	0.253	0.250	0.252	0.248	0.253	0.250	0.252	0.249	0.254	0.251	0.253	0.249
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	0.008	0.000	0.008	-0.001	0.008	0.000	0.008	-0.001	0.008	0.000	0.008	-0.001
GDP (% change vs. baseline)	-0.5	-0.8	-0.5	-0.8	-0.6	-0.9	-0.5	-0.8	-0.6	-0.9	-0.5	-0.8
CO2 emissions (% change vs. baseline)	-16.4	-17.0	-16.7	-17.2	-16.5	-17.1	-16.8	-17.3	-16.4	-16.9	-16.6	-17.1
ETS	-18.7	-19.7	-19.0	-20.1	-18.5	-19.5	-18.9	-20.0	-18.4	-19.4	-18.7	-19.9
Energy demand (% change vs. baseline)	-3.8	-5.9	-3.4	-5.8	-4.0	-6.0	-3.5	-5.9	-4.0	-5.9	-3.4	-5.8
Electricity demand (% change vs. baseline)	4.2	3.2	6.5	4.2	4.5	3.4	6.7	4.3	4.2	3.3	6.7	4.3
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0
Electricity price (2010 €/MWh)	121	125	121	125	121	125	121	125	121	125	121	125

**Table 20: Regional macroeconomic and environmental impacts in 2030 – Italy**

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.302	0.298	0.303	0.299	0.302	0.298	0.303	0.299	0.301	0.297	0.303	0.299
ETS	0.127	0.125	0.129	0.126	0.128	0.125	0.129	0.126	0.127	0.125	0.129	0.126
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	-0.003	-0.008	-0.003	-0.008	-0.003	-0.008	-0.003	-0.008	-0.003	-0.008	-0.003	-0.008
GDP (% change vs. baseline)	-0.8	-1.1	-0.7	-1.1	-0.9	-1.2	-0.8	-1.1	-0.9	-1.2	-0.8	-1.1
CO2 emissions (% change vs. baseline)	-9.6	-10.7	-9.4	-10.6	-9.8	-10.9	-9.5	-10.6	-10.0	-11.0	-9.5	-10.6
ETS	-7.3	-9.2	-6.2	-8.2	-7.1	-9.2	-6.1	-8.2	-7.3	-9.2	-6.1	-8.2
Energy demand (% change vs. baseline)	-6.5	-8.2	-6.2	-8.0	-6.7	-8.4	-6.3	-8.1	-6.7	-8.4	-6.3	-8.0
Electricity demand (% change vs. baseline)	2.0	1.4	4.0	3.3	2.2	1.5	4.1	3.3	2.1	1.5	4.1	3.3
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	-0.3	-0.7	-0.2	-0.7	-0.3	-0.7	-0.2	-0.7	-0.3	-0.7	-0.2	-0.7
Electricity price (2010 €/MWh)	119	122	122	125	119	122	122	125	119	121	122	124

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**Table 21:** Regional macroeconomic and environmental impacts in 2030 – Poland

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.200	0.204	0.200	0.204	0.202	0.206	0.201	0.204	0.203	0.206	0.201	0.205
ETS	0.113	0.116	0.113	0.116	0.113	0.116	0.113	0.116	0.113	0.116	0.113	0.116
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	0.002	-0.001	0.001	-0.001	0.002	0.000	0.002	0.000	0.002	0.000	0.002	-0.001
GDP (% change vs. baseline)	0.1	-0.3	0.2	-0.2	0.8	0.3	0.4	-0.1	0.7	0.2	0.4	-0.1
CO2 emissions (% change vs. baseline)	-25.2	-23.7	-25.1	-23.5	-24.3	-22.9	-24.8	-23.4	-24.0	-22.6	-24.6	-23.2
ETS	-19.5	-17.4	-19.8	-17.6	-19.6	-17.5	-19.8	-17.6	-19.2	-17.1	-19.6	-17.4
Energy demand (% change vs. baseline)	-8.3	-10.2	-8.0	-10.0	-10.4	-11.9	-8.7	-10.4	-10.4	-11.9	-8.7	-10.4
Electricity demand (% change vs. baseline)	11.3	9.0	10.9	8.7	2.8	1.7	8.2	6.9	2.3	1.2	8.1	6.7
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.5	-0.2	0.4	-0.2	0.7	0.0	0.5	-0.1	0.6	0.0	0.5	-0.2
Electricity price (2010 €/MWh)	117	122	117	122	117	122	117	122	118	122	117	122





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**Table 23:** Regional macroeconomic and environmental impacts in 2030 – *United Kingdom*

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.223	0.224	0.224	0.225	0.224	0.225	0.225	0.226	0.225	0.225	0.225	0.226
ETS	0.058	0.056	0.058	0.056	0.057	0.056	0.057	0.056	0.057	0.056	0.057	0.056
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	0.003	0.001	0.003	0.001	0.004	0.001	0.004	0.001	0.004	0.001	0.003	0.001
GDP (% change vs. baseline)	-0.9	-0.8	-0.8	-0.7	-0.9	-0.8	-0.7	-0.6	-0.8	-0.7	-0.7	-0.6
CO2 emissions (% change vs. baseline)	-26.6	-26.3	-26.2	-25.9	-26.2	-26.0	-25.8	-25.6	-26.1	-25.9	-25.8	-25.6
ETS	-34.1	-36.2	-34.2	-36.2	-35.1	-37.0	-34.9	-36.8	-35.1	-37.0	-34.9	-36.8
Energy demand (% change vs. baseline)	-12.3	-13.0	-12.0	-12.7	-13.5	-13.9	-12.8	-13.3	-13.3	-13.7	-12.7	-13.2
Electricity demand (% change vs. baseline)	10.4	8.4	9.9	8.1	2.9	2.3	4.2	3.4	2.7	2.1	4.1	3.4
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.2	0.0	0.2	0.0	0.3	0.1	0.2	0.1	0.2	0.1	0.2	0.1
Electricity price (2010 €/MWh)	113	116	113	116	113	116	113	116	113	116	113	116



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Table 25: Regional macroeconomic and environmental impacts in 2030 – Rest of Eastern MS

<b>Macroeconomic and environmental ind.</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
CO2 emissions (Gt)	0.255	0.254	0.256	0.254	0.254	0.253	0.256	0.254	0.251	0.250	0.253	0.251
ETS	0.115	0.114	0.117	0.115	0.116	0.114	0.117	0.115	0.113	0.112	0.115	0.114
CO2 price ETS (2010 €)	74.7	68.5	75.7	69.1	74.1	67.9	75.3	68.8	74.0	67.7	75.1	68.5
CO2 price non-ETS (2010 €)	180	159	173	153	187	165	176	156	182	161	174	153
Cost of policy (change in consumption in trillion 2010 €)	-0.004	-0.007	-0.004	-0.006	-0.004	-0.007	-0.004	-0.006	-0.004	-0.007	-0.004	-0.006
GDP (% change vs. baseline)	-0.5	-0.8	-0.6	-0.9	-0.6	-0.9	-0.7	-0.9	-0.9	-1.2	-0.9	-1.2
CO2 emissions (% change vs. baseline)	-18.0	-18.4	-17.7	-18.3	-18.2	-18.6	-17.8	-18.3	-19.2	-19.7	-18.7	-19.2
ETS	-21.7	-22.5	-20.8	-21.8	-21.5	-22.4	-20.8	-21.7	-23.0	-23.9	-21.9	-22.9
Energy demand (% change vs. baseline)	-10.4	-11.8	-10.0	-11.5	-10.6	-12.0	-10.1	-11.6	-11.3	-12.7	-10.7	-12.2
Electricity demand (% change vs. baseline)	-7.5	-8.4	-5.5	-6.5	-7.4	-8.2	-5.4	-6.5	-8.5	-9.4	-6.3	-7.4
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	-0.8	-1.3	-0.7	-1.2	-0.8	-1.3	-0.7	-1.2	-0.8	-1.3	-0.7	-1.2
Electricity price (2010 €/MWh)	110	110	112	112	109	110	112	112	108	109	111	111

**Table 26:** Results of changes in sectoral output (% change vs. baseline) – EU28 aggregate in 2030

<b>Sectoral output (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Refined oil and coal products	2.5	-1.1	2.6	-1.2	2.1	-1.4	2.4	-1.3	1.7	-1.8	2.2	-1.5
Gas	-22.5	-16.1	-22.4	-16.0	-22.8	-16.3	-22.5	-16.1	-22.2	-15.9	-22.2	-15.9
Mining	-0.9	-1.4	-0.8	-1.3	-1.1	-1.6	-0.9	-1.4	-1.3	-1.8	-1.0	-1.5
Wood	-1.6	-0.9	-1.4	-0.7	-1.7	-1.0	-1.5	-0.8	-1.5	-0.8	-1.4	-0.7
Paper, pulp and printing	0.0	-0.2	-0.1	-0.2	0.0	-0.2	-0.1	-0.2	-0.4	-0.5	-0.2	-0.4
Fertilizers	0.9	-2.0	1.1	-1.9	0.8	-2.1	1.0	-1.9	0.7	-2.2	1.0	-2.0
Organic chemicals	2.8	-1.5	2.9	-1.4	2.8	-1.5	2.8	-1.5	2.4	-1.8	2.7	-1.6
Inorganic chemicals	1.0	-1.3	1.1	-1.2	0.9	-1.3	1.0	-1.3	0.7	-1.5	0.9	-1.4
Other chemicals, rubber, plastic	0.3	-3.9	0.7	-3.5	-0.1	-4.1	0.5	-3.6	0.2	-3.9	0.7	-3.6
Cement	0.2	-0.7	0.1	-0.8	0.2	-0.7	0.1	-0.8	-0.2	-1.0	0.0	-0.9
Bricks, tiles, construction products	0.4	-1.2	0.3	-1.3	0.4	-1.2	0.3	-1.3	-0.1	-1.6	0.1	-1.5
Glass	-0.3	-2.2	-0.4	-2.3	-0.2	-2.2	-0.3	-2.3	-0.8	-2.7	-0.6	-2.5
Ceramics	-1.4	-2.3	-1.5	-2.3	-1.4	-2.3	-1.5	-2.3	-1.9	-2.7	-1.8	-2.5
Other non-metallic minerals	-5.2	-5.9	-4.9	-5.7	-5.6	-6.2	-5.0	-5.8	-5.4	-6.0	-5.0	-5.7
Iron and steel - manufacturing	-1.5	-2.3	-1.7	-2.5	-1.4	-2.3	-1.6	-2.5	-2.7	-3.3	-2.3	-3.0
Iron and steel - further processing	-3.7	-6.2	-4.0	-6.5	-3.6	-6.2	-3.9	-6.5	-5.2	-7.5	-4.7	-7.1
Aluminium	-0.5	-1.5	-0.8	-1.8	-0.5	-1.5	-0.8	-1.8	-3.2	-3.8	-2.3	-3.1
Other non-ferrous metals	-1.3	-2.2	-1.5	-2.3	-1.2	-2.1	-1.5	-2.3	-3.2	-3.7	-2.5	-3.1
Motor vehicles	-0.8	-0.3	-0.8	-0.3	-0.8	-0.3	-0.8	-0.3	-0.8	-0.3	-0.7	-0.3
Transport equipment	-2.4	-0.1	-2.3	-0.1	-2.4	-0.1	-2.4	-0.1	-2.3	-0.1	-2.3	-0.1

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<b>Sectoral output (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Electricity	1.1	-0.1	2.3	0.9	-0.5	-1.4	1.5	0.3	-0.7	-1.6	1.4	0.2
Machinery and equipment	-1.6	-0.1	-1.6	-0.1	-1.6	-0.1	-1.6	-0.1	-1.6	-0.1	-1.6	-0.1
Other manufacturing	-0.8	-0.4	-0.7	-0.4	-0.8	-0.4	-0.8	-0.4	-0.9	-0.5	-0.8	-0.4
Construction	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Inland transport	-2.9	-3.9	-2.7	-3.7	-3.1	-4.0	-2.8	-3.8	-3.0	-4.0	-2.8	-3.8
Water transport	-3.5	-3.7	-3.3	-3.5	-3.6	-3.8	-3.4	-3.6	-3.5	-3.7	-3.3	-3.5
Air transport	1.1	-4.0	1.0	-4.1	1.2	-4.0	1.1	-4.0	1.0	-4.1	1.0	-4.1
Coal	-22.0	-9.8	-22.0	-9.9	-22.0	-9.8	-22.0	-9.9	-21.8	-9.7	-21.9	-9.8
Crude oil	-1.5	-0.7	-1.4	-0.6	-1.6	-0.7	-1.5	-0.7	-1.6	-0.7	-1.5	-0.7
Electronic equipment	-1.1	-0.1	-1.0	-0.1	-1.3	-0.3	-1.1	-0.1	-1.0	-0.1	-0.9	0.0
Agriculture, forestry and fishing	-2.3	-2.0	-2.2	-1.9	-2.4	-2.1	-2.2	-1.9	-2.3	-2.0	-2.1	-1.9
Food and beverages	-1.3	-1.1	-1.2	-1.1	-1.3	-1.2	-1.2	-1.1	-1.2	-1.1	-1.2	-1.0
Textiles, wearing apparel, leather	-0.7	-0.3	-0.6	-0.3	-0.7	-0.3	-0.6	-0.3	-0.4	-0.1	-0.5	-0.2
Business services	-0.4	-0.2	-0.4	-0.2	-0.4	-0.2	-0.4	-0.2	-0.4	-0.2	-0.3	-0.2
Private services	0.5	0.4	0.4	0.4	0.5	0.4	0.5	0.4	0.5	0.4	0.5	0.4
Public services	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1

**Table 27: Sectoral shares in global market and changes in percentage points compared to baseline – EU28 aggregate in 2030**

<b>World market share</b>	int		uni		int_ren		uni_ren		int_1		uni_1		int_ren_1		uni_ren_1		int_2		uni_2		int_ren_2		uni_ren_2	
Refined oil and coal products	19.9	0.6	19.3	-0.1	19.9	0.6	19.3	-0.1	19.8	0.5	19.2	-0.1	19.9	0.5	19.2	-0.1	19.8	0.5	19.2	-0.2	19.9	0.5	19.2	-0.1
Gas	4.3	-1.2	4.2	-1.4	4.3	-1.2	4.2	-1.4	4.3	-1.2	4.2	-1.4	4.3	-1.2	4.2	-1.4	4.4	-1.2	4.2	-1.3	4.4	-1.2	4.2	-1.3
Mining	6.5	0.0	6.4	0.0	6.5	0.0	6.4	0.0	6.5	0.0	6.4	0.0	6.5	0.0	6.4	0.0	6.4	0.0	6.4	-0.1	6.5	0.0	6.4	-0.1
Wood	17.3	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1	17.3	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1	17.4	-0.1
Paper, pulp and printing	23.8	0.1	23.7	-0.1	23.8	0.1	23.7	-0.1	23.8	0.1	23.6	-0.1	23.8	0.1	23.7	-0.1	23.8	0.1	23.6	-0.1	23.8	0.1	23.6	-0.1
Fertilizers	11.3	0.1	11.0	-0.2	11.3	0.2	11.0	-0.2	11.3	0.1	11.0	-0.2	11.3	0.2	11.0	-0.2	11.3	0.1	11.0	-0.2	11.3	0.2	11.0	-0.2
Organic chemicals	14.3	0.4	13.8	-0.2	14.4	0.4	13.8	-0.2	14.3	0.4	13.8	-0.2	14.4	0.4	13.8	-0.2	14.3	0.3	13.8	-0.2	14.3	0.4	13.8	-0.2
Inorganic chemicals	14.4	0.1	14.2	-0.2	14.5	0.1	14.2	-0.1	14.4	0.1	14.2	-0.2	14.5	0.1	14.2	-0.1	14.4	0.1	14.2	-0.2	14.5	0.1	14.2	-0.1
Other chemicals, rubber, plastic	17.8	0.2	17.1	-0.5	17.9	0.3	17.2	-0.4	17.8	0.2	17.1	-0.5	17.9	0.3	17.2	-0.4	17.8	0.2	17.1	-0.5	17.9	0.3	17.2	-0.4
Cement	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0	15.2	0.0
Bricks, tiles, construction products	16.2	0.1	16.1	-0.1	16.2	0.1	16.1	-0.1	16.2	0.1	16.1	-0.1	16.2	0.1	16.1	-0.1	16.2	0.0	16.1	-0.1	16.2	0.0	16.1	-0.1
Glass	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1	13.6	0.1	13.4	-0.1
Ceramics	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0	3.4	0.0
Other non-metallic minerals	10.5	-0.1	10.4	-0.1	10.5	0.0	10.4	-0.1	10.5	-0.1	10.4	-0.1	10.5	0.0	10.4	-0.1	10.5	-0.1	10.4	-0.1	10.5	-0.1	10.4	-0.1
Iron and steel - manufacturing	7.6	0.0	7.5	-0.1	7.6	-0.1	7.5	-0.1	7.6	0.0	7.5	-0.1	7.6	-0.1	7.5	-0.1	7.5	-0.1	7.5	-0.1	7.5	-0.1	7.5	-0.1
Iron and steel - further processing	12.1	-0.2	11.8	-0.5	12.1	-0.2	11.8	-0.5	12.1	-0.2	11.8	-0.5	12.1	-0.2	11.8	-0.5	12.0	-0.3	11.7	-0.6	12.0	-0.3	11.7	-0.6
Aluminium	9.3	0.0	9.2	-0.1	9.3	0.0	9.1	-0.1	9.3	0.0	9.2	-0.1	9.3	0.0	9.2	-0.1	9.1	-0.2	9.0	-0.3	9.2	-0.1	9.1	-0.2
Other non-ferrous metals	10.0	-0.1	9.9	-0.2	10.0	-0.1	9.9	-0.2	10.0	0.0	9.9	-0.2	10.0	-0.1	9.9	-0.2	9.9	-0.2	9.8	-0.3	9.9	-0.1	9.8	-0.3
Motor vehicles	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0	22.5	0.0
Transport equipment	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0	20.7	-0.4	21.1	0.0
Electricity	16.5	-0.6	17.8	0.6	17.0	-0.1	18.3	1.2	16.2	-0.9	17.5	0.4	16.8	-0.3	18.2	1.1	16.1	-1.0	17.4	0.3	16.8	-0.3	18.2	1.0

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<b>World market share</b>	int		uni		int_ren		uni_ren		int_1		uni_1		int_ren_1		uni_ren_1		int_2		uni_2		int_ren_2		uni_ren_2	
Machinery and equipment	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0	18.0	-0.2	18.1	0.0
Other manufacturing	19.2	0.0	19.2	0.0	19.2	0.0	19.2	0.0	19.2	0.0	19.2	0.0	19.2	0.0	19.2	0.0	19.2	-0.1	19.2	-0.1	19.2	0.0	19.2	-0.1
Construction	16.7	0.1	16.6	0.0	16.7	0.1	16.6	0.0	16.7	0.1	16.6	0.0	16.7	0.1	16.6	0.0	16.7	0.1	16.6	0.0	16.7	0.1	16.6	0.0
Inland transport	20.8	0.1	20.7	-0.1	20.8	0.1	20.7	-0.1	20.8	0.1	20.6	-0.1	20.8	0.1	20.7	-0.1	20.8	0.1	20.6	-0.1	20.8	0.1	20.7	-0.1
Water transport	24.5	-0.2	24.5	-0.2	24.6	-0.2	24.5	-0.2	24.5	-0.2	24.5	-0.2	24.6	-0.2	24.5	-0.2	24.5	-0.2	24.5	-0.2	24.6	-0.2	24.5	-0.2
Air transport	22.9	0.2	22.3	-0.4	22.9	0.2	22.3	-0.5	23.0	0.2	22.3	-0.4	22.9	0.2	22.3	-0.4	22.9	0.2	22.3	-0.5	22.9	0.2	22.3	-0.5
Coal	3.4	-0.5	3.3	-0.6	3.4	-0.5	3.3	-0.6	3.4	-0.5	3.3	-0.6	3.4	-0.5	3.3	-0.6	3.5	-0.5	3.3	-0.6	3.5	-0.5	3.3	-0.6
Crude oil	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0
Electronic equipment	7.7	0.0	7.7	0.0	7.7	0.0	7.7	0.0	7.7	-0.1	7.7	0.0	7.7	0.0	7.7	0.0	7.7	0.0	7.7	0.0	7.7	0.0	7.7	0.0
Agriculture, forestry and fishing	7.7	0.0	7.6	-0.1	7.7	0.0	7.6	-0.1	7.6	0.0	7.6	-0.1	7.7	0.0	7.6	-0.1	7.7	0.0	7.6	-0.1	7.7	0.0	7.6	-0.1
Food and beverages	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1	17.7	0.0	17.6	-0.1
Textiles, wearing apparel, leather	11.8	0.0	11.7	0.0	11.8	0.0	11.7	0.0	11.8	0.0	11.7	0.0	11.8	0.0	11.7	0.0	11.8	0.0	11.8	0.0	11.8	0.0	11.8	0.0
Business services	21.5	0.2	21.3	-0.1	21.5	0.2	21.3	-0.1	21.5	0.2	21.3	-0.1	21.5	0.2	21.3	-0.1	21.5	0.1	21.3	-0.1	21.5	0.2	21.3	-0.1
Private services	20.4	0.3	20.1	-0.1	20.4	0.3	20.1	-0.1	20.4	0.3	20.1	-0.1	20.4	0.3	20.1	-0.1	20.4	0.3	20.1	-0.1	20.4	0.3	20.1	-0.1
Public services	21.8	0.2	21.6	-0.1	21.8	0.2	21.6	-0.1	21.8	0.2	21.6	-0.1	21.8	0.2	21.6	-0.1	21.8	0.2	21.6	-0.1	21.8	0.2	21.6	-0.1

**Table 28:** Results of changes in sectoral revenues (% change vs. baseline) – EU28 aggregate in 2030

<b>Sectoral revenues (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Refined oil and coal products	-2.3	-2.4	-1.9	-2.3	-3.0	-2.9	-2.2	-2.5	-2.9	-2.9	-2.2	-2.5
Gas	-39.9	-30.0	-39.9	-30.0	-40.2	-30.2	-40.0	-30.1	-39.5	-29.7	-39.6	-29.8
Mining	-1.2	-2.0	-1.1	-1.9	-1.4	-2.2	-1.2	-1.9	-1.7	-2.4	-1.3	-2.1
Wood	-2.6	-1.9	-2.4	-1.7	-2.8	-2.0	-2.4	-1.7	-2.6	-1.9	-2.3	-1.7
Paper, pulp and printing	-1.7	-1.7	-1.5	-1.6	-1.8	-1.9	-1.6	-1.6	-1.8	-1.8	-1.5	-1.6
Fertilizers	0.1	-2.8	0.4	-2.6	-0.1	-3.0	0.3	-2.7	-0.1	-3.0	0.3	-2.6
Organic chemicals	1.4	-2.6	1.6	-2.4	1.2	-2.8	1.6	-2.5	1.2	-2.8	1.6	-2.5
Inorganic chemicals	-0.6	-2.5	-0.3	-2.3	-0.8	-2.7	-0.4	-2.4	-0.6	-2.5	-0.3	-2.3
Other chemicals, rubber, plastic	0.0	-4.0	0.4	-3.7	-0.4	-4.3	0.3	-3.8	-0.1	-4.1	0.4	-3.7
Cement	-1.0	-1.6	-0.8	-1.4	-1.2	-1.7	-0.9	-1.5	-1.0	-1.6	-0.8	-1.4
Bricks, tiles, construction products	-0.3	-1.7	-0.2	-1.5	-0.5	-1.8	-0.2	-1.6	-0.4	-1.7	-0.2	-1.5
Glass	-0.3	-2.1	-0.1	-1.9	-0.4	-2.2	-0.2	-2.0	-0.4	-2.2	-0.2	-2.0
Ceramics	-1.4	-2.0	-1.2	-1.9	-1.5	-2.2	-1.3	-2.0	-1.5	-2.2	-1.3	-2.0
Other non-metallic minerals	-1.2	-2.3	-1.0	-2.1	-1.4	-2.5	-1.1	-2.2	-1.3	-2.4	-1.0	-2.2
Iron and steel - manufacturing	-2.4	-2.9	-2.2	-2.8	-2.5	-3.0	-2.3	-2.9	-2.8	-3.3	-2.5	-3.0
Iron and steel - further processing	-3.0	-5.5	-3.0	-5.5	-3.1	-5.5	-3.1	-5.5	-4.0	-6.3	-3.5	-5.9
Aluminium	-1.8	-2.8	-1.9	-2.8	-1.9	-2.9	-1.9	-2.9	-3.8	-4.5	-2.9	-3.7
Other non-ferrous metals	-2.4	-3.2	-2.3	-3.2	-2.4	-3.2	-2.4	-3.2	-3.8	-4.3	-3.0	-3.7
Motor vehicles	-2.1	-1.6	-1.9	-1.5	-2.2	-1.7	-2.0	-1.5	-2.1	-1.6	-1.9	-1.4
Transport equipment	-3.8	-1.5	-3.6	-1.4	-4.0	-1.7	-3.7	-1.4	-3.8	-1.5	-3.6	-1.4



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<b>Sectoral revenues (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Electricity	-0.9	0.0	1.6	2.1	-2.6	-1.5	0.7	1.4	-2.8	-1.7	0.5	1.3
Machinery and equipment	-2.9	-1.5	-2.8	-1.3	-3.1	-1.6	-2.9	-1.4	-3.0	-1.5	-2.8	-1.3
Other manufacturing	-2.0	-1.7	-1.9	-1.6	-2.2	-1.8	-1.9	-1.6	-2.1	-1.8	-1.9	-1.6
Construction	-1.6	-1.5	-1.4	-1.4	-1.7	-1.7	-1.5	-1.4	-1.6	-1.6	-1.4	-1.4
Inland transport	-1.2	-1.7	-1.0	-1.5	-1.4	-1.8	-1.1	-1.6	-1.3	-1.7	-1.1	-1.5
Water transport	-2.2	-1.8	-2.0	-1.7	-2.3	-1.9	-2.0	-1.7	-2.2	-1.8	-2.0	-1.7
Air transport	0.6	-3.3	0.8	-3.2	0.5	-3.4	0.7	-3.2	0.6	-3.3	0.8	-3.2
Coal	-39.0	-19.5	-38.9	-19.3	-39.2	-19.6	-38.9	-19.4	-38.9	-19.3	-38.8	-19.2
Crude oil	-5.8	-2.1	-5.5	-2.0	-6.2	-2.5	-5.7	-2.1	-6.2	-2.4	-5.7	-2.1
Electronic equipment	-2.5	-1.5	-2.2	-1.3	-2.8	-1.8	-2.4	-1.4	-2.4	-1.5	-2.2	-1.3
Agriculture, forestry and fishing	-2.6	-2.3	-2.4	-2.1	-2.8	-2.4	-2.5	-2.2	-2.6	-2.3	-2.4	-2.1
Food and beverages	-2.1	-1.9	-1.9	-1.8	-2.2	-2.1	-2.0	-1.8	-2.1	-2.0	-1.9	-1.8
Textiles, wearing apparel, leather	-2.0	-1.7	-1.8	-1.6	-2.1	-1.8	-1.9	-1.6	-1.9	-1.6	-1.7	-1.5
Business services	-2.0	-1.8	-1.8	-1.6	-2.1	-1.9	-1.8	-1.7	-2.0	-1.8	-1.8	-1.6
Private services	-1.6	-1.8	-1.4	-1.7	-1.7	-1.9	-1.5	-1.7	-1.6	-1.8	-1.4	-1.7
Public services	-1.8	-1.8	-1.6	-1.6	-2.0	-1.9	-1.7	-1.7	-1.9	-1.9	-1.7	-1.6

**Table 29:** Results of changes in sectoral employment (% change vs. baseline) – EU28 aggregate in 2030

<b>Sectoral employment (% change vs. baseline)</b>	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Refined oil and coal products	0.2	-1.9	0.6	-1.7	-0.5	-2.4	0.2	-2.0	-0.5	-2.4	0.2	-2.0
Gas	-33.1	-26.0	-32.7	-25.6	-33.7	-26.5	-32.9	-25.8	-33.1	-26.0	-32.6	-25.6
Mining	-2.0	-2.6	-1.8	-2.4	-2.3	-2.7	-1.9	-2.5	-2.6	-3.0	-2.1	-2.6
Wood	-3.2	-2.5	-2.9	-2.3	-3.5	-2.8	-3.0	-2.4	-3.4	-2.7	-3.0	-2.3
Paper, pulp and printing	-2.3	-2.4	-2.0	-2.2	-2.5	-2.6	-2.1	-2.3	-2.5	-2.6	-2.1	-2.3
Fertilizers	-1.5	-4.1	-1.0	-3.8	-1.9	-4.4	-1.2	-3.9	-1.6	-4.3	-1.1	-3.8
Organic chemicals	0.2	-3.7	0.6	-3.5	-0.1	-4.0	0.5	-3.5	-0.1	-4.0	0.5	-3.5
Inorganic chemicals	-1.5	-3.5	-1.1	-3.2	-1.8	-3.8	-1.3	-3.3	-1.7	-3.7	-1.2	-3.3
Other chemicals, rubber, plastic	-1.1	-5.1	-0.5	-4.7	-1.6	-5.5	-0.8	-4.9	-1.4	-5.3	-0.7	-4.8
Cement	-2.0	-2.5	-1.6	-2.2	-2.2	-2.7	-1.7	-2.3	-1.9	-2.5	-1.6	-2.2
Bricks, tiles, construction products	-1.8	-3.0	-1.5	-2.7	-2.0	-3.2	-1.6	-2.8	-1.8	-3.0	-1.5	-2.7
Glass	-2.3	-4.0	-2.1	-3.7	-2.6	-4.2	-2.2	-3.8	-2.5	-4.1	-2.1	-3.7
Ceramics	-3.5	-4.0	-3.2	-3.7	-3.7	-4.2	-3.3	-3.8	-3.6	-4.1	-3.2	-3.8
Other non-metallic minerals	-4.4	-5.2	-4.1	-4.9	-4.8	-5.5	-4.3	-5.0	-4.7	-5.4	-4.2	-5.0
Iron and steel - manufacturing	-2.2	-2.6	-1.9	-2.3	-2.4	-2.8	-2.0	-2.4	-2.0	-2.4	-1.7	-2.2
Iron and steel - further processing	-4.5	-6.6	-4.3	-6.5	-4.6	-6.7	-4.4	-6.5	-4.8	-6.8	-4.4	-6.5
Aluminium	-2.8	-3.5	-2.7	-3.4	-3.0	-3.7	-2.8	-3.5	-4.3	-4.7	-3.4	-4.0
Other non-ferrous metals	-3.6	-4.3	-3.4	-4.2	-3.8	-4.4	-3.5	-4.2	-4.8	-5.2	-3.9	-4.5
Motor vehicles	-2.7	-2.2	-2.5	-2.0	-2.9	-2.4	-2.6	-2.1	-2.9	-2.3	-2.6	-2.1
Transport equipment	-4.1	-2.0	-3.9	-1.9	-4.3	-2.2	-4.0	-1.9	-4.2	-2.1	-3.9	-1.9

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Sectoral employment (% change vs. baseline)	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2
Electricity	0.8	0.5	3.7	3.6	-1.7	-1.4	2.2	2.6	-1.9	-1.6	2.1	2.5
Machinery and equipment	-3.6	-2.2	-3.4	-2.0	-3.9	-2.4	-3.5	-2.1	-3.8	-2.3	-3.5	-2.0
Other manufacturing	-2.7	-2.3	-2.4	-2.1	-2.9	-2.5	-2.5	-2.2	-2.9	-2.5	-2.6	-2.2
Construction	-2.3	-2.3	-2.1	-2.0	-2.6	-2.5	-2.2	-2.1	-2.5	-2.4	-2.1	-2.1
Inland transport	-3.0	-3.7	-2.7	-3.4	-3.3	-3.9	-2.9	-3.5	-3.2	-3.9	-2.8	-3.5
Water transport	-3.4	-3.2	-3.1	-2.9	-3.7	-3.4	-3.3	-3.0	-3.6	-3.3	-3.2	-3.0
Air transport	-1.2	-5.5	-1.0	-5.3	-1.4	-5.6	-1.0	-5.3	-1.3	-5.5	-1.0	-5.3
Coal	-35.1	-17.3	-35.0	-17.2	-35.4	-17.6	-35.1	-17.3	-35.1	-17.3	-35.0	-17.1
Crude oil	-5.2	-3.7	-4.8	-3.4	-5.6	-4.1	-5.0	-3.6	-5.6	-4.1	-5.1	-3.7
Electronic equipment	-2.9	-2.0	-2.6	-1.8	-3.2	-2.2	-2.8	-1.9	-3.0	-2.0	-2.7	-1.8
Agriculture, forestry and fishing	-2.7	-2.5	-2.4	-2.2	-3.0	-2.7	-2.5	-2.3	-2.9	-2.6	-2.5	-2.2
Food and beverages	-2.7	-2.6	-2.5	-2.4	-2.9	-2.8	-2.6	-2.5	-2.8	-2.7	-2.5	-2.5
Textiles, wearing apparel, leather	-2.4	-2.2	-2.2	-2.0	-2.6	-2.3	-2.3	-2.1	-2.4	-2.2	-2.1	-1.9
Business services	-2.5	-2.3	-2.2	-2.1	-2.7	-2.5	-2.3	-2.2	-2.6	-2.4	-2.3	-2.1
Private services	-1.9	-2.0	-1.7	-1.8	-2.1	-2.2	-1.8	-1.9	-2.0	-2.1	-1.7	-1.9
Public services	-2.2	-2.2	-2.0	-2.0	-2.4	-2.4	-2.1	-2.0	-2.4	-2.3	-2.0	-2.0

**Table 30:** Export intensities for selected sectors

<b>Sector</b>	<b>Export intensity (exports/production)</b>
Other non-ferrous metals	0.306
Air transport	0.290
Other chemicals, rubber, plastic	0.276
Iron and steel - further processing	0.262
Aluminium	0.261
Organic chemicals	0.182
Fertilizers	0.173
Glass	0.116
Bricks, tiles, construction products	0.101
Other non-metallic minerals	0.086
Iron and steel - manufacturing	0.077
Paper, pulp and printing	0.074
Refined oil and coal products	0.069
Inorganic chemicals	0.057
Cement	0.041
Crude oil	0.038
Electricity	0.023
Ceramics	0.022

**Table 31:** Import intensities for selected sectors

<b>Sector</b>	<b>Import intensity (imports/production)</b>
Crude oil	5.134
Aluminium	0.594
Other non-ferrous metals	0.363
Ceramics	0.341
Air transport	0.228
Other chemicals, rubber, plastic	0.200
Iron and steel - further processing	0.189
Refined oil and coal products	0.151
Fertilizers	0.144
Organic chemicals	0.133
Glass	0.097
Other non-metallic minerals	0.091
Iron and steel - manufacturing	0.080
Paper, pulp and printing	0.038
Inorganic chemicals	0.035
Cement	0.031
Bricks, tiles, construction products	0.027
Electricity	0.011

**Table 32:** Energy intensities for selected sectors

<b>Sector</b>	<b>Energy intensity (toe/M€ of production)</b>
Refined oil and coal products	289
Iron and steel - manufacturing	142
Iron and steel - further processing	139
Air transport	98.6
Cement	86.5
Glass	83.5
Bricks, tiles, construction products	83.2
Other non-metallic minerals	76.7
Crude oil	53.7
Ceramics	52.0
Paper, pulp and printing	50.1
Aluminium	43.1
Other non-ferrous metals	36.1
Inorganic chemicals	32.9
Other chemicals, rubber, plastic	29.8
Organic chemicals	27.8
Fertilizers	12.7

**Table 33:** Results of changes in sectoral energy demand (% change vs. baseline) – EU28 aggregate in 2030

Energy demand (% change vs. baseline)			int_ren		uni_ren		int_ren		uni_ren		int_ren		uni_ren	
	int	uni	int_ren	uni_ren	int_1	uni_1	int_ren_1	uni_ren_1	int_2	uni_2	int_ren_2	uni_ren_2	int_ren_2	uni_ren_2
Refined oil and coal products	6.4	-0.2	6.5	-0.2	5.9	-0.5	6.3	-0.4	5.7	-0.7	6.2	-0.4		
Gas	-34.3	-27.0	-34.0	-26.7	-34.8	-27.4	-34.1	-26.8	-34.1	-26.8	-33.8	-26.6		
Mining	-16.5	-17.8	-15.0	-16.5	-18.8	-19.7	-15.9	-17.1	-18.5	-19.4	-15.7	-17.0		
Wood	-18.4	-17.7	-16.4	-16.1	-19.9	-19.0	-16.9	-16.5	-18.9	-18.1	-16.4	-16.0		
Paper, pulp and printing	-2.9	-3.6	-3.0	-3.7	-2.8	-3.5	-3.0	-3.7	-3.8	-4.3	-3.4	-3.8		
Fertilizers	2.6	-2.1	2.8	-1.9	2.5	-2.2	2.7	-2.0	2.3	-2.3	2.7	-2.0		
Organic chemicals	4.6	-1.5	4.6	-1.5	4.5	-1.5	4.6	-1.5	4.0	-2.0	4.4	-1.7		
Inorganic chemicals	2.4	-1.5	2.5	-1.4	2.4	-1.5	2.5	-1.4	2.1	-1.7	2.4	-1.5		
Other chemicals, rubber, plastic	-6.1	-10.6	-5.2	-9.9	-6.8	-11.1	-5.5	-10.1	-6.3	-10.8	-5.3	-9.9		
Cement	-2.4	-5.0	-2.6	-5.1	-2.4	-4.9	-2.5	-5.0	-3.1	-5.6	-2.9	-5.3		
Bricks, tiles, construction products	-2.2	-5.6	-2.4	-5.7	-2.1	-5.5	-2.3	-5.6	-3.1	-6.3	-2.9	-6.1		
Glass	-3.1	-6.7	-3.3	-6.9	-3.0	-6.7	-3.3	-6.9	-4.1	-7.6	-3.8	-7.3		
Ceramics	-4.4	-6.7	-4.6	-6.8	-4.3	-6.7	-4.5	-6.8	-5.3	-7.5	-5.1	-7.3		
Other non-metallic minerals	-26.8	-27.0	-25.7	-26.1	-27.9	-27.9	-26.2	-26.5	-27.3	-27.4	-25.9	-26.3		
Iron and steel - manufacturing	-8.8	-10.4	-9.2	-10.7	-8.6	-10.3	-9.1	-10.7	-12.0	-13.1	-10.8	-12.2		
Iron and steel - further processing	-12.5	-15.7	-13.0	-16.1	-12.3	-15.5	-12.9	-16.0	-15.7	-18.2	-14.4	-17.3		
Aluminium	-1.5	-4.5	-2.0	-4.9	-1.4	-4.4	-2.0	-4.8	-7.3	-9.4	-5.4	-7.7		
Other non-ferrous metals	-2.2	-4.9	-2.5	-5.2	-2.0	-4.8	-2.5	-5.2	-6.1	-8.0	-4.4	-6.7		
Motor vehicles	-18.4	-17.9	-16.2	-16.3	-19.8	-19.0	-16.8	-16.7	-18.8	-18.2	-16.3	-16.3		
Transport equipment	-17.4	-15.6	-15.4	-14.0	-19.5	-17.4	-16.4	-14.8	-18.5	-16.6	-15.9	-14.4		
Machinery and equipment	-14.5	-13.2	-13.4	-12.4	-15.4	-14.0	-13.8	-12.7	-14.8	-13.5	-13.6	-12.5		
Other manufacturing	-17.8	-17.4	-15.7	-15.8	-19.2	-18.6	-16.4	-16.3	-18.4	-17.9	-16.0	-16.0		
Construction	-18.2	-18.5	-17.0	-17.5	-19.3	-19.4	-17.5	-17.8	-18.6	-18.8	-17.1	-17.5		
Inland transport	-5.7	-6.9	-5.3	-6.6	-6.0	-7.2	-5.5	-6.7	-5.9	-7.1	-5.4	-6.7		
Water transport	-5.7	-6.3	-5.4	-6.1	-5.9	-6.5	-5.5	-6.1	-5.8	-6.4	-5.4	-6.1		
Air transport	0.7	-4.7	0.7	-4.7	0.8	-4.6	0.7	-4.7	0.7	-4.7	0.6	-4.7		
Coal	-34.1	-17.4	-34.0	-17.3	-34.2	-17.4	-34.0	-17.3	-34.0	-17.2	-33.9	-17.1		
Crude oil	-2.7	-1.3	-2.6	-1.2	-2.8	-1.4	-2.7	-1.3	-2.8	-1.4	-2.7	-1.3		
Electronic equipment	-20.1	-19.5	-18.2	-18.0	-22.3	-21.4	-19.1	-18.7	-21.2	-20.4	-18.6	-18.2		
Agriculture, forestry and fishing	-23.6	-23.0	-22.5	-22.1	-24.5	-23.8	-23.0	-22.3	-23.9	-23.3	-22.6	-22.1		
Food and beverages	-24.0	-23.4	-22.7	-22.3	-25.1	-24.2	-23.2	-22.6	-24.4	-23.6	-22.8	-22.3		
Textiles, wearing apparel, leather	-25.7	-25.4	-23.4	-23.5	-27.3	-26.7	-24.2	-24.1	-25.9	-25.5	-23.4	-23.4		
Business services	-17.1	-16.8	-15.9	-15.8	-18.4	-17.8	-16.5	-16.2	-17.7	-17.3	-16.2	-16.0		
Private services	-10.5	-10.6	-9.0	-9.4	-11.6	-11.4	-9.5	-9.7	-10.9	-10.9	-9.2	-9.5		
Public services	-12.6	-12.4	-11.2	-11.3	-13.9	-13.5	-11.9	-11.8	-13.2	-12.9	-11.6	-11.5		

**Table 34:** Results of changes in sectoral electricity demand (% change vs. baseline) – EU28 aggregate in 2030

Electricity demand (% change vs. baseline)			int_ren		uni_ren		int_ren		uni_ren		int_ren		uni_ren	
	int	uni	int_ren	uni_ren	int_1	uni_1	int_1	uni_1	int_2	uni_2	int_2	uni_2	int_2	uni_2
Refined oil and coal products	8.4	8.2	8.4	8.1	8.4	8.2	8.3	8.1	7.6	7.6	8.0	7.8		
Gas	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
Mining	1.2	1.2	1.2	1.2	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.2		
Wood	2.3	2.3	2.3	2.3	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3		
Paper, pulp and printing	18.3	18.1	18.2	18.1	18.3	18.1	18.2	18.1	17.5	17.5	17.9	17.8		
Fertilizers	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2		
Organic chemicals	0.9	0.8	0.9	0.8	0.9	0.8	0.9	0.8	0.8	0.8	0.8	0.8		
Inorganic chemicals	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Other chemicals, rubber, plastic	6.3	6.0	6.4	6.1	6.1	5.9	6.4	6.1	6.2	6.0	6.4	6.1		
Cement	2.4	2.3	2.4	2.3	2.4	2.3	2.4	2.3	2.2	2.2	2.3	2.2		
Bricks, tiles, construction products	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3		
Glass	1.3	1.3	1.3	1.2	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2		
Ceramics	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Other non-metallic minerals	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7		
Iron and steel - manufacturing	9.0	8.8	8.9	8.7	9.0	8.8	8.9	8.7	8.2	8.1	8.5	8.4		
Iron and steel - further processing	7.4	7.1	7.4	7.1	7.5	7.1	7.4	7.1	6.8	6.7	7.1	6.9		
Aluminium	1.8	1.7	1.8	1.7	1.8	1.7	1.8	1.7	1.6	1.6	1.6	1.6		
Other non-ferrous metals	3.0	2.9	3.0	2.9	3.0	2.9	3.0	2.9	2.8	2.8	2.9	2.8		
Motor vehicles	3.4	3.4	3.5	3.5	3.3	3.3	3.5	3.5	3.4	3.4	3.5	3.5		
Transport equipment	1.1	1.1	1.2	1.2	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.2		
Machinery and equipment	6.4	6.5	6.5	6.6	6.3	6.4	6.5	6.5	6.4	6.4	6.5	6.6		
Other manufacturing	3.8	3.8	4.0	3.9	3.8	3.8	3.9	3.9	3.8	3.8	3.9	3.9		
Construction	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9		
Inland transport	4.7	4.7	4.8	4.8	4.6	4.5	4.8	4.7	4.6	4.6	4.8	4.7		
Water transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Air transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Coal	0.8	1.0	0.8	1.0	0.8	1.0	0.8	1.0	0.8	1.0	0.8	1.0		
Crude oil	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Electronic equipment	1.3	1.3	1.4	1.4	1.3	1.3	1.4	1.4	1.3	1.3	1.4	1.4		
Agriculture, forestry and fishing	3.2	3.2	3.3	3.3	3.1	3.2	3.3	3.3	3.2	3.2	3.3	3.3		
Food and beverages	10.3	10.2	10.5	10.4	10.1	10.1	10.4	10.4	10.2	10.2	10.5	10.4		
Textiles, wearing apparel, leather	1.3	1.3	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.3		
Business services	44.1	43.9	45.0	44.7	43.1	43.1	44.5	44.3	43.6	43.5	44.7	44.5		
Private services	5.8	5.8	6.0	5.9	5.8	5.7	5.9	5.9	5.8	5.8	5.9	5.9		
Public services	32.3	32.2	33.0	32.7	31.8	31.7	32.6	32.5	32.0	32.0	32.8	32.6		





**Table 36:** Results of changes in sectoral coal demand (% change vs. baseline) – EU28 aggregate in 2030

Coal demand (% change vs. baseline)							int_ren		uni_ren		int_ren		uni_ren	
	int	uni	int_ren	uni_ren	int_1	uni_1	_1	_1	int_2	uni_2	_2	_2		
Refined oil and coal products	2.8	2.4	2.8	2.4	2.8	2.4	2.8	2.4	2.8	2.4	2.8	2.4		
Gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Paper, pulp and printing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0		
Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Organic chemicals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Inorganic chemicals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Other chemicals, rubber, plastic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Cement	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Bricks, tiles, construction products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Glass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Ceramics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Other non-metallic minerals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Iron and steel - manufacturing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Iron and steel - further processing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Aluminium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Other non-ferrous metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Transport equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Machinery and equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Other manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Inland transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Water transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Air transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Crude oil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Electronic equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Agriculture, forestry and fishing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Food and beverages	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Textiles, wearing apparel, leather	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Business services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Private services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Public services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		



**Table 38:** Selected macroeconomic and environmental impacts in different world regions in 2030

Macroeconomic and environmental ind.	int				uni			
	EU28	Other Annex I	Non-Annex I	World	EU28	Other Annex I	Non-Annex I	World
CO2 emissions (Gt)	2.373	8.742	24.566	35.680	2.373	12.411	24.818	39.602
GDP (% change vs. baseline)	-0.7	-2.7	-1.9	-2.0	-0.9	-1.5	-1.5	-1.4
CO2 emissions (% change vs. baseline)	-16.9	-29.5	-1.0	-10.0	-16.9	0.1	0.0	-1.1
Welfare (Hicksian Equivalent Variation - % change vs. baseline)	0.1	-1.5	-0.4	-0.9	-0.3	-0.3	-0.1	-0.2

**Table 39:** CO<sub>2</sub> prices in non-EU regions in Scenario *int*

CO2 prices (2010 €)	int
Australia	42.0
China	3.7
Japan	103.8
South Korea	238.0
Indonesia	172.3
India	4.8
Canada	68.6
United States	137.8
Mexico	127.5
Brazil	0.0
Russia	38.2
Turkey	0.0
South Africa	15.4
Rest of Annex I	9.0

**Table 40:** Changes in sectoral output (% change vs. baseline) in different world regions in 2030

Sectoral output (% change vs. baseline)	int				uni			
	EU28	Other Annex I	Non-Annex I	World	EU28	Other Annex I	Non-Annex I	World
Refined oil and coal products	2.5	-6.7	1.7	-0.9	-1.1	0.1	0.1	-0.1
Gas	-22.5	-18.3	-4.7	-11.4	-16.1	-1.6	-1.5	-2.3
Mining	-0.9	-1.9	0.3	-0.2	-1.4	0.2	0.0	0.0
Wood	-1.6	-0.1	-0.2	-0.4	-0.9	0.1	0.0	-0.1
Paper, pulp and printing	0.0	-1.6	0.1	-0.5	-0.2	0.0	0.0	0.0
Fertilizers	0.9	-10.4	1.6	-0.7	-2.0	0.2	0.2	0.0
Organic chemicals	2.8	-12.4	2.4	-1.3	-1.5	0.2	0.2	0.0
Inorganic chemicals	1.0	-8.8	1.2	-1.6	-1.3	0.2	0.1	0.0
Other chemicals, rubber, plastic	0.3	-11.8	3.3	-1.0	-3.9	0.9	0.5	-0.1
Cement	0.2	-6.4	0.3	-0.9	-0.7	0.1	0.0	-0.1
Bricks, tiles, construction products	0.4	-6.9	0.4	-1.0	-1.2	0.3	0.1	-0.1
Glass	-0.3	-10.7	1.2	-0.8	-2.2	0.5	0.1	-0.1
Ceramics	-1.4	-11.2	0.4	-0.4	-2.3	0.1	0.0	0.0
Other non-metallic minerals	-5.2	-8.3	1.0	-0.8	-5.9	0.8	0.3	-0.2
Iron and steel - manufacturing	-1.5	-5.8	0.4	-1.2	-2.3	0.3	0.0	-0.1
Iron and steel - further processing	-3.7	-8.0	2.0	-1.1	-6.2	1.1	0.4	-0.2
Aluminium	-0.5	-4.5	1.2	-0.7	-1.5	0.4	0.0	0.0
Other non-ferrous metals	-1.3	-5.5	1.3	-0.6	-2.2	0.4	0.1	0.0
Motor vehicles	-0.8	-0.3	-0.1	-0.3	-0.3	-0.1	0.0	-0.1
Transport equipment	-2.4	2.3	-0.7	-0.1	-0.1	-0.1	0.0	-0.1
Electricity	1.1	-9.5	0.2	-3.3	-0.1	0.2	0.1	0.1
Machinery and equipment	-1.6	1.0	-0.6	-0.3	-0.1	-0.1	0.0	0.0
Other manufacturing	-0.8	-0.6	-0.2	-0.4	-0.4	0.0	0.0	-0.1
Construction	0.0	-0.3	0.0	-0.1	0.1	0.0	0.0	0.0
Inland transport	-2.9	-4.9	0.7	-1.6	-3.9	0.3	0.3	-0.5
Water transport	-3.5	-3.0	0.7	-1.1	-3.7	0.9	0.8	-0.2
Air transport	1.1	-9.0	2.7	-2.0	-4.0	0.6	0.7	-0.3
Coal	-22.0	-29.2	-10.0	-17.0	-9.8	-2.1	-1.1	-1.8
Crude oil	-1.5	-1.3	-1.0	-1.1	-0.7	0.0	-0.1	-0.1
Electronic equipment	-1.1	0.5	-0.6	-0.3	-0.1	-0.1	0.0	-0.1
Agriculture, forestry and fishing	-2.3	-1.5	0.0	-0.4	-2.0	0.0	0.0	-0.1
Food and beverages	-1.3	-1.3	-0.2	-0.6	-1.1	0.0	0.0	-0.2
Textiles, wearing apparel, leather	-0.7	-0.8	-0.4	-0.5	-0.3	0.0	-0.1	-0.1
Business services	-0.4	-0.1	-0.2	-0.2	-0.2	0.0	0.0	-0.1
Private services	0.5	-0.2	-0.3	-0.1	0.4	0.0	-0.1	0.0
Public services	0.0	-0.1	-0.1	-0.1	0.1	0.0	0.0	0.0

**Table 41:** Changes in sectoral revenues (% change vs. baseline) in different world regions in 2030

Sectoral revenues (% change vs. baseline)	int				uni			
	EU28	Other Annex I	Non-Annex I	World	EU28	Other Annex I	Non-Annex I	World
Refined oil and coal products	-2.3	-8.9	-3.5	-5.0	-2.4	-1.9	-1.8	-2.0
Gas	-39.9	-33.4	-14.2	-23.6	-30.0	-6.1	-5.8	-7.3
Mining	-1.2	-3.4	-1.3	-1.8	-2.0	-1.3	-1.4	-1.4
Wood	-2.6	-2.0	-2.0	-2.1	-1.9	-1.3	-1.4	-1.4
Paper, pulp and printing	-1.7	-2.8	-1.5	-2.0	-1.7	-1.4	-1.4	-1.5
Fertilizers	0.1	-7.2	0.3	-1.2	-2.8	-1.1	-1.2	-1.4
Organic chemicals	1.4	-7.8	1.1	-1.3	-2.6	-1.2	-1.3	-1.4
Inorganic chemicals	-0.6	-3.9	-0.1	-1.3	-2.5	-1.2	-1.3	-1.4
Other chemicals, rubber, plastic	0.0	-9.2	1.9	-1.4	-4.0	-0.6	-0.9	-1.4
Cement	-1.0	0.3	-1.0	-0.7	-1.6	-1.3	-1.4	-1.4
Bricks, tiles, construction products	-0.3	-0.6	-0.8	-0.7	-1.7	-1.2	-1.3	-1.3
Glass	-0.3	-4.6	-0.2	-0.9	-2.1	-0.9	-1.3	-1.3
Ceramics	-1.4	-5.3	-0.8	-1.2	-2.0	-1.2	-1.4	-1.4
Other non-metallic minerals	-1.2	-2.5	-0.3	-0.7	-2.3	-0.7	-1.1	-1.1
Iron and steel - manufacturing	-2.4	-3.2	-1.2	-1.7	-2.9	-1.2	-1.4	-1.4
Iron and steel - further processing	-3.0	-5.6	0.5	-1.5	-5.5	-0.4	-1.0	-1.4
Aluminium	-1.8	-4.6	-0.4	-1.9	-2.8	-1.1	-1.4	-1.4
Other non-ferrous metals	-2.4	-5.7	-0.3	-1.8	-3.2	-1.0	-1.3	-1.4
Motor vehicles	-2.1	-2.1	-1.7	-1.9	-1.6	-1.5	-1.4	-1.5
Transport equipment	-3.8	-0.3	-2.4	-2.0	-1.5	-1.5	-1.4	-1.5
Electricity	-0.9	14.1	-1.5	4.4	0.0	-1.7	-1.6	-1.4
Machinery and equipment	-2.9	-1.3	-2.1	-2.0	-1.5	-1.5	-1.4	-1.4
Other manufacturing	-2.0	-2.2	-1.6	-1.9	-1.7	-1.4	-1.4	-1.5
Construction	-1.6	-2.8	-1.7	-2.0	-1.5	-1.4	-1.4	-1.4
Inland transport	-1.2	-2.7	-1.3	-1.7	-1.7	-1.2	-1.2	-1.3
Water transport	-2.2	-2.0	-0.9	-1.5	-1.8	-0.3	-0.6	-0.9
Air transport	0.6	-2.0	0.9	-0.3	-3.3	-0.9	-0.7	-1.4
Coal	-39.0	-48.5	-20.8	-30.9	-19.5	-5.7	-3.7	-5.0
Crude oil	-5.8	-7.5	-6.6	-6.8	-2.1	-1.9	-2.0	-2.0
Electronic equipment	-2.5	-1.3	-2.2	-1.9	-1.5	-1.5	-1.4	-1.4
Agriculture, forestry and fishing	-2.6	-3.0	-1.9	-2.1	-2.3	-1.4	-1.4	-1.5
Food and beverages	-2.1	-3.2	-2.0	-2.3	-1.9	-1.5	-1.4	-1.5
Textiles, wearing apparel, leather	-2.0	-2.6	-2.0	-2.1	-1.7	-1.4	-1.5	-1.5
Business services	-2.0	-3.6	-1.9	-2.7	-1.8	-1.5	-1.4	-1.5
Private services	-1.6	-3.6	-2.4	-2.9	-1.8	-1.4	-1.5	-1.5
Public services	-1.8	-3.5	-1.8	-2.6	-1.8	-1.5	-1.4	-1.5

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