

ONLINE SUPPLEMENTAL MATERIAL

A.1 Additional Data

Table A-1 National-average net carbon price and ETS results for 2018

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Consumer subsidies	€ -1.09	€ -0.64	€ -2.58	-	-	€ -0.37	€ -0.01	-
Further subsidies	€ -0.16	€ -0.14	€ -0.00	€ -3,45	€ -0.37	€ -0.29	€ -1.30	
Net tax rate	€ 6.47	€ 12.82	€ 13.81	€ 0.00	€ 30.02	€ 51.67	€ 26.70	€ 106.13
ETS price effect*	€ 0.40	€ 0.74	-	-	-	€ 9.79	€ 12.80	€ 6.58
Negative price IEA	€ -4.39	-	€ -15.93	€ -19.76	-	-	-	-

*For the US and China data on emission coverage and caps in the ETS systems was not always available for the year 2018 so we had to use different years. Since the share of national emissions that are covered are very small, this will have little effect of the resulting prices.

Table A-2 Transport sector average net carbon price and ETS results for 2018

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Consumer subsidies	€ -11.62	€ -0.44			€ -0.03	€ -0.42		
Further subsidies	€ -0.30	€ -0.07		€ -19.42	€ -0.54			
Net tax rate	€ 61.45	€ 37.47	€ 76.77	€ 0.02	€ 141.95	€ 210.58	€ 130.55	€ 198.41
ETS price effect		€ 0.99				€ 1.36	€ 0.51	€ 3.41

Table A-3 Industrial sector average net carbon price and ETS results for 2018

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Consumer subsidies	€ -0.00	€ -0.17	€ -0.06			€ -0.73		
Further subsidies	€ -0.19	€ -0.14	€ -0.06	€ -0.03	€ -0.14	€ -1.02	€ -0.94	
Net tax rate	€ 1.70	€ 0.01	€ 7.26	€ 0.00	€ 4.32	€ 3.62	€ 11.60	€ 14.07
ETS price effect	€ 0.47	€ 0.73				€ 5.49	€ 10.54	€ 8.54

Table A-4 Residential and commercial sector average net carbon price and ETS results
for 2018

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Consumer subsidies	€ -1.15	€ -3.74	€ -40.30				€ -0.08	
Further subsidies	€ -0.34	€ -0.15	€ -0.00	€ -5.07	€ -0.51		€ -1.34	
Net tax rate	€ 4.66		€ 1.02	€ 0.00	€ 19.74	€ 26.80	€ 2.48	€ 150.20
ETS price effect		€ -0.97						

Table A-5 Electricity sector average net carbon price and ETS results for 2018

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Consumer subsidies		€ -0.13	€ -0.00					
Further subsidies	€ -0.06	€ -0.19	€ -0.01	€ -0.05	€ -0.44	€ -0.21	€ -2.13	
Net tax rate	€ 0.01		€ 3.04	€ 0.00	€ 5.37			
ETS price effect	€ 0.47	€ 0.45				€ 24.48	€ 24.48	€ 24.48

Table A-6 Sector emission share (2018) - Overview

	China	USA	India	Russia	Japan	Germany	Poland	Sweden
Total combustion emis. (Mt CO ₂)	9744	5006	2131	1609	1215	773	310	42
Transport sector	9%	34%	13%	15%	17%	22%	18%	48%
Industrial sector	47%	18%	39%	54%	32%	28%	28%	44%
Residential/Commercial	6%	11%	6%	10%	11%	18%	14%	3%
Electricity sector	38%	37%	42%	21%	40%	32%	40%	5%

Source: OECD (2019)

A.2 Details on fuel and carbon tax data from the OECD TEU report

The TEU report shares net tax rate data per end-use sector, but also per fuel to a degree. Usually, the two or three most consumed fuels per sector are reported individually, with the remaining fuels being summarized under a miscellaneous category. As fuel usage patterns differ between countries, the fuels that are reported individually in the TEU report vary between countries and sectors. Due to this mixed reporting, we do not publish per fuel results, although we internally allocated negative carbon prices on a fuel level where it was possible based on the TEU data. Both sector and per fuel reporting offers insights into the structure of effective fossil fuel pricing and future TEU reports may share data in more detail, making a per fuel calculation of net carbon prices easier. At the moment, more detailed data are only shared graphically in the TEU's country notes¹.

It is possible to calculate detailed per-fuel net tax rates from tax and consumption data shared by countries, but the matching of tax rates to consumption statistics is not straightforward. For example, Germany's fuel tax rates are differentiated by different sector boundaries than those used by Eurostat. Also, some tax rate differentiation is based on firm size or on fuel characteristics (e.g. sulfur content in diesel fuel), which again is not reported by Eurostat.

We explored creating our own dataset on net fuel tax rates for Germany from primary sources, with our country-average results differing from the TEU results by 4%. We decided to use the TEU data on net tax rates instead of our own calculations due to

¹ See tab "Tax and the environment" at <https://www.oecd.org/tax/tax-policy/tax-database/>

the data-constraints described above. Without the TEU data, it would have been more difficult to include especially developing countries like China, which tend to be less transparent in sharing tax and consumption data.

One modification of the TEU data we made was that we omitted net tax rate data on biofuels from the net carbon price calculation. The OECD TEU report includes biofuels in its tax overview, arguing that biofuels are usually not emission neutral as shown by life cycle analysis (OECD, 2018). We do not include biofuels in our analysis, however instead following the biofuel classification of the UNFCCC.

A.3 Details on sector attribution for emission trading systems

The EU ETS covers electricity and heat generation, certain industrial activities and aviation. In its ETS data viewer (EEA, 2021), the EEA only differentiates between stationary combustion and aviation for combustion-related emissions. We therefore had to estimate the share of emissions for the electricity and industrial sector, while all aviation emissions were attributed to the transport sector. As virtually all emissions related to electricity generation are covered by the EU ETS² and stationary combustion activities only cover the electricity and industrial sector, we assume that total stationary

² Some small operations are excluded from EU ETS obligations, but this likely applies mainly to industry and not to generally large-scale electricity generation facilities powered by fossil fuels. See the EU Commissions EU ETS overview for details: https://ec.europa.eu/clima/policies/ets_en#tab-0-0

combustion emissions minus electricity-sector emissions equal industrial sector emissions.

For the U.S., we included the three currently active regional ETS schemes: the California Cap and Trade (CaT) scheme which covers about 80% of California's CO₂ emissions (ICAP, 2021); the Regional Greenhouse Gas Initiative (RGGI) which covers the electricity sector of ten eastern US states; and the Massachusetts ETS, which puts an additional price on emissions in the Massachusetts electricity sector, which is also already covered by the RGGI scheme. California's CaT does not cover all emissions in all sectors. We assume that the 80% coverage figure is equally distributed across sectors.³ As the value for California only adds € 0.82/tCO₂ to the nationwide average price, any inaccuracy in sector attribution of California's CaT does not have a significant impact on overall results.

For the year of our analysis, China had eight regional ETS test schemes in operation, which cover electricity and industrial emissions in these jurisdictions⁴.

³ The World Bank's Carbon Pricing Dashboard reports California's Sector emissions including non-combustion emissions (World Bank, 2021). We therefore assumed that 50% of California's Industrial sector emissions are from fossil fuel combustion, which is the U.S. countrywide share in the industrial sector (IEA, 2021).

⁴ Some regional schemes cover a small share of transport emissions from public transport or regional aviation. We did not factor in transport sector ETS coverage because of the insignificant coverage and impact.

Because regional sector emissions statistics are not available, we assume the national sector share for the regional ETS schemes and allocate the price effect accordingly. We estimate the overall countrywide price impact of the ETS schemes at € 0.48/tCO₂.

A significant number of permits are still allocated freely to firms based on past emissions. This allocation is, however, not counted as a subsidy here because the allocation provides no marginal effect and they do not undermine the ETS's incentive for emission abatement, as the freely allocated subsidies can be sold off in case firms reduce emissions.

A.4 Details on subsidy data from the OECD Inventory of Support Measures for Fossil Fuels

In its fossil fuel support database⁵, the OECD Inventory provides supplemental information on each individual subsidy measure. This information is usually sufficient to determine whether the measure fits our definition for negative carbon prices. To determine negative carbon prices for a country and per sector, we first remove all fuel-tax subsidies covered in the TEU report and then consider which of the remaining measures have a marginal impact on consumption or production of fossil fuels. We also identify if the measures potentially affect exports of fossil fuels and if yes, multiply them by share of this fossil fuel that is not exported. This is only relevant for the USA and Russia,

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https://stats.oecd.org/Index.aspx?DataSetCode=FFS_DEU&_ga=2.47427623.1279122295.1621935900-1399138561.1621525647

otherwise the export share is either zero or there are no subsidies which relate to exports.

Table A-8 shows the export shares we derived from IEA data on country balances and

Table A-9 our categorization.

Table A-7 Export shares of different fuels

	Coal	Crude Oil	Natural Gas
USA	19%	18%	12%
Russia	56%	47%	33%

Source: IEA (2022).

We then identify which of our four sectors the subsidy affects, with measures covering multiple sectors being attributed by share of consumption – e.g. a measure subsidizing coal in the electricity and industrial sector would be attributed to both sectors based on how much coal is consumed in these sectors. This attribution is not precise, since the actual sector-share of the subsidization is not known and thus has to be estimated but it is standard practice. The estimation in turn is based on the fuel-share reported in the OECD Inventory. The OECD Inventory attributes the total subsidization amount of a measure to individual fuels, since country documents and reports which serve as the data source for the OECD Inventory usually only report the total subsidization amount for a measure, not the share benefitting individual fuels. The Inventory's attribution to individual fuels seems to assume a uniform subsidy per unit of energy, according to our observations when comparing subsidization estimations from different sources for Germany. This likely only yields a rough approximation for many measures, as factors determining the subsidy amount can differ between fuels even for the same measure. For example, a fuel tax exemption will benefit some fuels more than others, based on the non-subsidized rates of the affected fuels.

These issues should, however, not majorly affect the robustness of our results for two reasons. First, the attribution issue in the OECD Inventory mostly affects fuel tax exemptions, which we do not incorporate as subsidies into our results. Second, many subsidies or net fuel tax rates affect only one sector, and since we aggregate to sector level and do not present results for individual fuels, this will mostly not alter the results. If measures are attributed to different sectors, the influence of this misattribution will depend on how much consumption shares of these fuels differ between sectors. However, on a country-average level these misattributions will not affect results at all, since they do not change the overall subsidy or tax amounts.

To assess completeness of the subsidy measures listed in the OECD Inventory, we compared the subsidies listed in the OECD Inventory for Germany with the IfW's own subsidy report⁶ and to the subsidy report published by the German finance ministry (BMF, 2017). While mostly identical, we found that some federal subsidies were not reported in the OECD Inventory, for example subsidies on fuels used in combined heat and power plants (CHP). However, the differences only applied to fuel-tax subsidies and were therefore not relevant for our analysis. We did not analyze differences for other countries but assume that subsidies tend to be underestimated, especially in federal countries where individual states or other government entities can implement their own subsidy policies (on which data are less readily available) or in countries which are less transparent.

6 <https://www.ifw-kiel.de/publications/kieler-beitraege-zur-wirtschaftspolitik/kiel-subsidy-report-2020-subsidies-on-the-rise-14952/>

A.5 Categorization of Subsidies

Table A-8 Categorization of subsidies that are not part of the OECD-TEU report

Subsidy Measure	Included in NCP	Justification**	Classification
<i>Germany*</i>			
Compensation for Mothballing and Closing of Lignite-fired Power Plants	No	Related to closing plants	
Early Retirement Payments for Hard Coal Miners in North Rhine Westphalia and Saarland	No	„Labor“	
Combined Aids for coal in North Rhine Westphalia	Yes		Producer support
Rehabilitation of Lignite Mining Sites in East Germany	No	Related to closed sites	
Energy Tax Relief for Public Transportation	Yes		Consumer support
Peak Equalisation Scheme	Yes		Consumer support
Mining Royalty Exemptions	Yes		Producer support
Water Fee Exemptions	Yes		Producer support
<i>Poland</i>			
NFOSiGW Aid for Environmental Protection	Yes		
Severance Payments for the Coal Mining Industry	No	„Labor“	
Coal Allowances in Coal Mining Sector	Yes		Consumer support
Early Retirement Benefits for Laid Off Miners	No	„Labor“	
Stranded Costs Compensations	Yes		Producer support, not export related
Initial Investment Aid for NATGAS investments	Yes		
Investment Aid for Coal Mining sector 2015-2018	Yes		Producer support
<i>USA</i>			
Marginal Wells Credit	Yes		Producer support
Capital Gains Treatment of Royalties on Coal	Yes		Producer support
Expensing of Exploration and Development Costs	No	Negative value	
Excess of Percentage over Cost Depletion	Yes		Producer support
Amortisation of Geological and Geophysical Expenditure	No	„Knowledge“	
Accelerated Depreciation of Natural Gas Distribution Pipelines	Yes		Producer support
Exception from Passive Loss Limitation	Yes		Producer support
Temporary Expensing of Equipment for Refining	No	Negative values	
Low-Income Home Energy Assistance Program	Yes		Consumer support
Strategic Petroleum Reserve	No	Reserve	
Fossil Energy R&D	No	„Knowledge“	
Northeast Home Heating Oil Reserve	No	Reserve	
Development Credit for Small Producers & New Areas	Yes		Producer Support
Coal Refuse Energy and Reclamation Tax Credit	Yes		Consumer support
Non Utility Sales of Natural Gas	Yes		Consumer support
Industrial Expansion and Revitalization Credit	Yes		Consumer support
Credit for Reducing Utility Charges	Yes		Consumer support
Exclusion of Low Volume Oil & Gas Wells	Yes		Producer support
Reduced Tax for Thin-Seamed Coal	Yes		Producer support
Percentage Depletion of Mineral and Other Resources	Yes		Producer support

Diverse Sales Tax Exemptions	Yes		Consumer support
Thin Seam Tax Credit	Yes		Producer support
Excess of Percentage over Cost Depletion	Yes		Producer support
Railroad Improvement Tax Credit	Yes		Producer Support
Natural Gas or Oil Severance Tax Suspension	Yes		Producer support
Diverse Reduced Severance Taxes	Yes		Producer support
Excess of Percentage over Cost Depletion	Yes		Producer support
Gross Production Tax Exemption for O&G Owned by Government	Yes		Producer support
Gas Marketing Deduction Against Gross Production Tax	Yes		Producer support
Nonrefundable Tax Credit for the Purchase of Oklahoma Mined Coal	Yes		Consumer support
Coal Used in the Manufacture of Electricity	Yes		Consumer support
Sales of Electricity	No	Electricity based support	
Sales-Tax Exclusion for Purchase of Electric Power or Energy for Non-residential Use	No	Electricity based support	
Credit for Ad Valorem Tax on Natural Gas and on Offshore Vessels	Yes		Consumer support
Sales Tax Exemption for Oil & Gas Equipment	Yes		Producer support
Sales-Tax Exclusion for Installation of Board Roads in Oil-fields	No	Electricity based support	
Sales-Tax Exemption for Repairs and Materials Used on Drilling Rigs	No	Electricity based support	
Departm. for Energy Development and Independence	No	„Knowledge“	
Coal Academy Mining Workforce Development	No	„Labor“	
Mine Safety and Licensing	No	„Labor“	
Enhanced Oil Recovery Commission	No	„Knowledge“	
Oil and Gas Research Fund	No	„Knowledge“	
Oil and Gas Impact Grant Fund	Yes		
Abandoned Oil and Gas Well Plugging & Site Reclamation Fund	Yes		
Coal Development Trust Fund	Yes		
Abandoned Mine Reclamation Fund	Yes		
Wyoming Oil and Gas Conservation Commission	No	„Knowledge“	
<i>China*</i>			
VAT Rebate on Imported Natural Gas Attributable to PetroChina and on LNG	Yes		Producer support
Resource-Tax Abatements and Refunds for Oil and Gas Extraction	Yes		Producer support
VAT Reduction for Natural Gas and Coal for Home Use	Yes		Consumer support
Petroleum Fuels Price Reform Support Programmes	Yes		Consumer support
Support Measures for Coal-Bed Methane Producers	Yes		Producer support
2012-15 Shale-Gas Subsidy	Yes		Producer support
Provincial Coal Safety Fund	Yes		Producer support
Heating Subsidy	Yes		Consumer support
Provincial Coal Exploration and mining and washing	Yes		Producer support
Ningxia Coal Design Research Center	No	„Knowledge“	
Provincial Petroleum Fuels Price Reform Support	Yes		Consumer support
<i>India*</i>			
Promotional (Regional) Exploration in Coal and Lignite	No	„Knowledge“	
Detailed Drilling Non-CIL Blocks	No	„Knowledge“	
MoC's contribution to Coal Mines Pension Scheme & Deposit Linked Insurance Scheme	No	„Labor“	
Lump-sum provision for North Eastern Region & Sikkim	Yes		Producer Support
Cash Incentive to States and Union Territories for Kerosene Distribution Reforms	Yes		Consumer support

Pradhan Mantri Ujjwala Yojana LPG Connection Scheme	Yes		Consumer support
Direct Benefit Transfer Scheme - LPG & Kerosene	Yes		Consumer support
Subsidies to Oil Companies for Transporting Natural Gas to the Northeastern Region	Yes		Consumer support
Compensation for Under-recoveries Incurred by Downstream Oil Companies	Yes		Consumer support
Indian Strategic Petroleum Reserves Ltd	No	Reserves	
Coal Research and Development Programme	No	„Knowledge“ Related to damage by mining operations before the nationalisation of coal mines	
Coal Environmental Measures and Subsidence Control	No		
<i>Russia</i>			
Different Tax Reductions for Newly Developed or offshore and onshore Oilfields in Specific Regions	Yes		Producer support
Tax Reductions for Gas and Condensate Produced on the Yamal Peninsula	Yes		Producer support
Various exemptions from the Extraction Tax	Yes		Producer support
Deductions for Investment in Occupational Safety and Health Protection	Yes		Producer support
Federal Budget Spending on Exploration and Prospecting for Coal and Hydrocarbons	No	„Knowledge“	Producer Support
Federal Support for Restructuring and Development of the Coal Industry	Yes		
<i>Japan</i>			
Oil Product Quality Assurance Subsidy	No	„Knowledge“	Producer support
Large-Scale Oil Disaster Prevention Subsidy	Yes		Producer support
Project Expenses for the Promotion of Oil and Natural Gas Development	No	„Knowledge“	
Projects for Development Support of Oil and Natural Gas Producing Countries	No	„Knowledge“	
Capital Contributions for Exploitation Rights and Assets Investment	Yes		Producer support
Project Expenses for the Measures to Increase Government Stockpiled Oil	No	Reserves	
Commission Expenses for the Management of Government Stockpiling Facilities and Stock-piled Oil /LPG in Preparation for Emergency Release	No	Reserves	
Project for Supporting Filling Stations to Maintain them as Regional Energy Supply Bases	Yes		
Interest Subsidy for Oil and LPG Reserves	No	Reserves	Producer support
Interest Subsidy for the Domestic Oil and Natural Gas Development Fund	Yes		Producer Support
Interest Subsidy for Capital Investment on Facilities Utilised to Procure Natural Gas	Yes		
Subsidy for Oil Stockpiling Project	No	Reserves	
Project Expenses for Overseas Geological Surveys in Risky Areas	No	„Knowledge“	
Stockpiling Project Expenses	No	„Knowledge“	
Project for Supporting Filling Stations to Maintain and Reinforce the Oil Products Distribution Network	Yes		

Support Project for Motor Gasoline Distribution Cost for Remote Islands	Yes		Consumer support
Interest Subsidy for Oil Industry's Overseas Expansion Fund	Yes		Producer support
Overseas Coal Exploration & Development Support	Yes		Producer support
Project for Improving the Productivity of Japan's Petro-chemical Complexes and their Capacity to Deal with Emergency	No	„Knowledge“	
Coal Producing Countries' Coal Exploration & Safety Technology Advancement Projects	No	„Knowledge“	
Commission Expenses to Enhance Safety of Oil Refineries	No	„Knowledge“	
Grant for Projects that Improve Welfare of Residents around Oil Stockpiling Facilities	No	welfare of residents	
Grant for Local Governments that are Hosting Government Oil and LPG Stockpiling Facilities in their Areas	No	grant to local government	
Petroleum RD&D Funding	No	„Knowledge“	

*Relevant Export shares for Japan, China, Germany and India are zero, so producer support measures can remain as they are.

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