Chapter 4

Effective carbon rates: Results of the analysis

This chapter presents the results of the analysis of effective carbon rates. It first discusses the patterns of carbon emissions in the 41 countries included in the analysis. This is followed by an overview of the level of effective carbon rates in the road and non-road sectors, a presentation of the effective carbon rates by country and the composition of effective carbon rates by price instrument, as well as an analysis of effective carbon rates in the five non-road sectors (offroad, industry, agriculture and fisheries, residential and commercial, and electricity). The chapter also discusses the treatment of biomass in the calculations of effective carbon rates. This chapter introduces the "carbon pricing gap", which measures the extent to which emissions are priced at less than EUR 30 per tonne of CO_2, and uses this indicator to consider a counterfactual scenario of carbon pricing. The chapter closes by correlating effective carbon rates with countries' broader macroeconomic characteristics.

This chapter presents the results of the analysis of effective carbon rates (ECRs) on energy use in 41 OECD and selected partner economies. Together, these countries accounted for 80% of global CO_2 emissions from energy use in 2012. Across these countries, ECRs are found to be low, particularly outside road transport: 96% of emissions from energy use outside road transport are subject to an ECR of less than EUR 30 per tonne and 70% of non-road emissions are entirely unpriced.

To measure the degree to which emissions in the 41 economies are not priced, or are priced at less than EUR 30 per tonne of CO_2, a "carbon pricing gap" indicator is developed, expressed as a percentage of the situation where all emissions would be priced at EUR 30 per tonne. Under the policies analysed in this report, the carbon pricing gap presently amounts to 80.1%. However, if all countries priced carbon in every sector at least as much as the median country, the carbon pricing gap would be reduced to just above 53%.

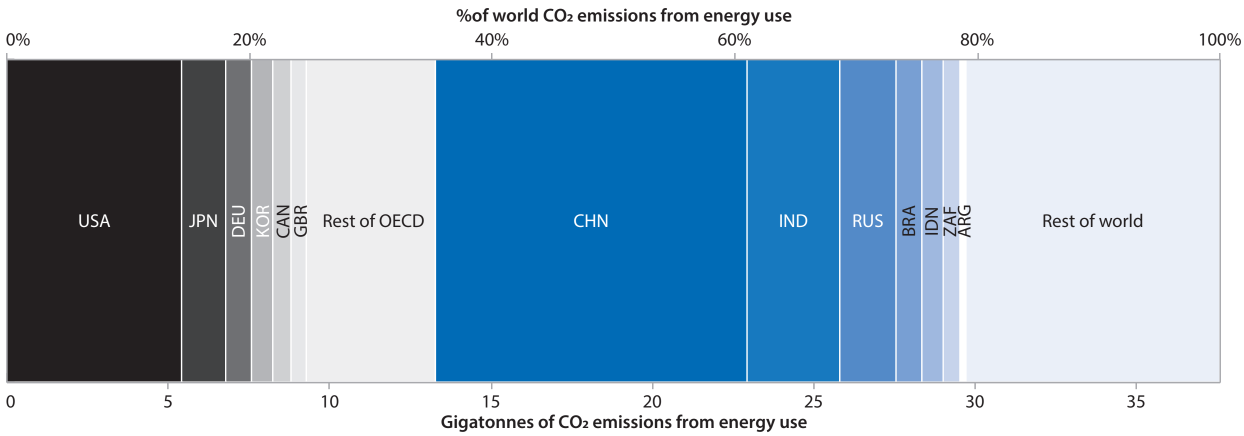
This chapter begins with an analysis of the patterns of CO_2 emissions to be considered when interpreting ECRs in the first section ("Patterns of CO_2 emissions from energy use in 41 countries"). The second section ("Effective carbon rates: Results of the analysis") presents detailed results of the analysis of ECRs in the 41 countries, considering first the results for the group of countries as a whole and economy-wide results for each country, distinguishing between road and all other emissions, before discussing the role of each of the three instruments in the road and non-road sectors. The second section continues by examining the pattern of effective carbon rates in non-road sectors more closely and finishes by considering the treatment of biomass emissions for countries with larger shares of energy from biomass. The third section ("Effective carbon rates: The bigger picture") considers the broader context, introducing the "carbon pricing gap" indicator and using it to assess the effects of potential future carbon pricing policies. Finally, correlations between countries' effective carbon rates and the carbon intensity of GDP, GDP per capita and the share of net energy imports are explored.

Patterns of CO_2 emissions from energy use in 41 countries

The 41 countries for which this report presents ECRs together account for about 80% of global CO_2 emissions from energy use in 2012 (Figure 4.1). The countries are the 34 OECD countries and seven selected partner economies, namely Argentina, Brazil, China, India, Indonesia, Russia and South Africa, all of which are G20 countries. In 2012, the OECD share of CO_2 emissions from energy use was around 35% and that of the selected partner economies around 44%. The share of the selected partner economies is expected to grow rapidly, along with their share in world output. The OECD's share in global output is expected to decline from 62% in 2013 to 43% in 2050 (Johanssen et al., 2013).

Countries differ strongly in terms of energy use per capita and in the carbon-intensity of energy use (Figure 4.2). Many of the countries for which energy use per capita is set to grow strongly currently rely on relatively carbon-intensive energy sources. In the figure, the curved dotted lines denote three different levels of CO_2 emissions per person (5, 7.5 and 10 tonnes of CO_2 per year), for each level of carbon intensity of energy use (vertical axis) and the corresponding level of energy use per capita (horizontal axis). To reduce CO_2 emissions per capita, countries face the challenge of moving towards the lower left corner of Figure 4.2, where CO_2 emissions per capita are low. Cutting CO_2 emissions per capita is a matter of reducing energy use per person, i.e. moving "left" in Figure 4.2, or a matter of decarbonising energy use, i.e. moving "down", or both. The mix of both approaches will differ between countries.

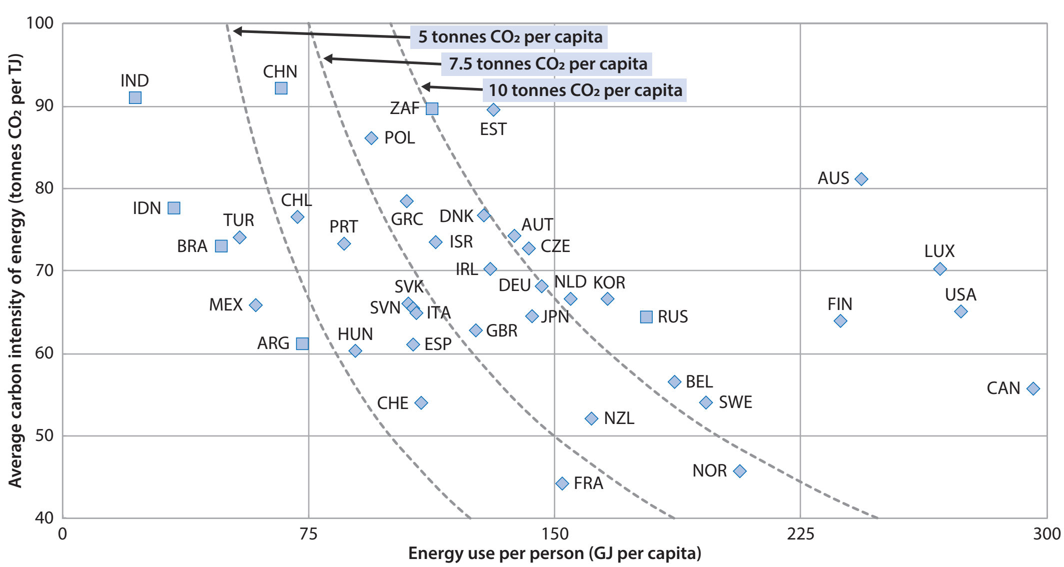
Figure 4.1. **OECD and selected partner economies account for the bulk of CO_2 emissions from energy use**



Note: CO_2 emissions data for 2012.

Source: OECD calculations based on OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, http://dx.doi.org/10.1787/9789264232334-en, and IEA (2016), "Extended world energy balances", *IEA World Energy Statistics and Balances* (database), http://dx.doi.org/10.1787/data-00513-en.

Figure 4.2. **Energy use per capita and carbon intensity vary widely across countries**



Note: The curved dotted lines show equal levels of CO_2 emissions per person and year, i.e. 5, 7.5 and 10 tonnes of CO_2 per capita. CO_2 emissions per person decrease when moving towards the lower left corner of the figure.

Source: Adapted from OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, http://dx.doi.org/10.1787/9789264232334-en.

Prices can provide incentives for moving "down" and "left". A price proportional to the energy content of a fuel can reduce energy use (horizontal axis), also reducing carbon emissions. A price based on the carbon content of the fuel discourages the use of carbon-based fuels and particularly carbon-intensive fuels. These prices can both decrease the carbon intensity of the energy mix (vertical axis) and reduce energy use (horizontal axis).

For example, a price based on the carbon content of a unit of energy from bituminous coal would be around 1.75 times as high as a price on the carbon content on a unit of energy from natural gas. A price based on energy content would be the same per unit of energy independent of the fuel. Pricing the carbon content of both fuels at the same rate would constitute a stronger signal to move to natural gas than would a price on energy content, because bituminous coal would be priced at a higher rate under a price based on carbon content than on a price based on energy content.

Figure 4.3 shows that the proportion of CO_2 emissions from energy use in each economic sector (road transport, offroad transport, industry, commercial & residential, agriculture & fishing, and electricity) varies widely across countries. The industry and electricity sectors each account for roughly a third of carbon emissions from energy use (33%), followed by the road sector, and the residential and commercial sector, which account for roughly 15% of emissions in all countries on average. Offroad transport, and agriculture and fishing emit 2% and 1% of carbon emissions from energy use, respectively.

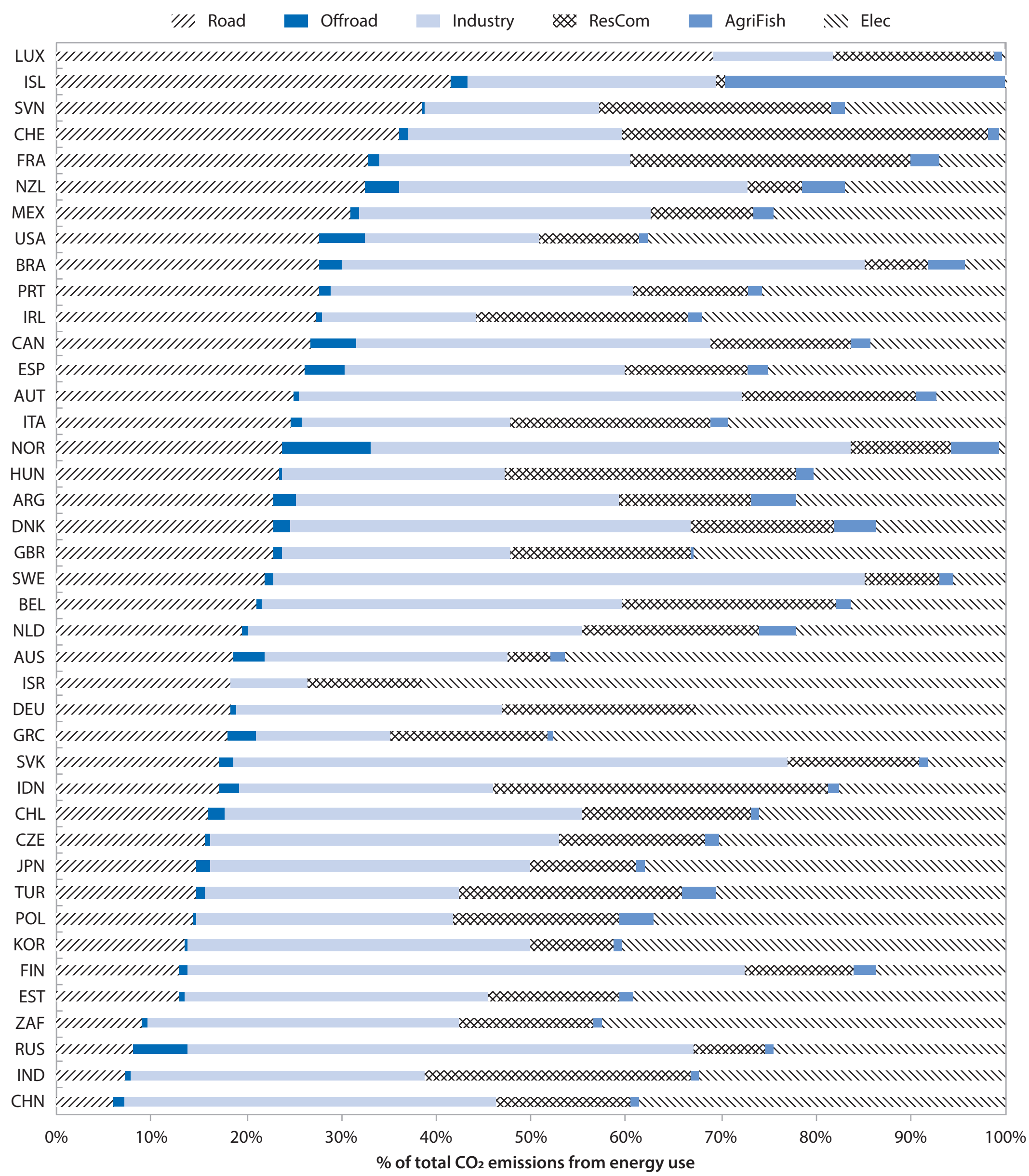
In road transport, the proportion of total emissions ranges from just 6% in China to 69% in Luxembourg. A general pattern is that CO_2 emissions from energy use in road transport tend to be higher in countries with a higher GDP per capita. A few small landlocked countries (Luxembourg, Switzerland and Slovenia) have a particularly high share of carbon emissions from road transport. In some of these countries, this is because of high shares of transit traffic in total road transport and because of non-residents filling up their vehicles, especially when transport fuels are priced at a lower level than abroad. Higher prices for transport fuels will likely lead to lower recorded emissions in these countries, but would largely be compensated by increases in nearby countries. The share of emissions from road transport in total emissions in Iceland is particularly high because of the high share of energy use generated from renewables causing no carbon emissions. Due to their particular characteristics, Iceland and Luxembourg are treated as outliers when citing ranges for the emissions from road transport.

Carbon emissions from energy use in industry range from about 10% of total emissions in Israel, Luxembourg and Greece to about 60% of total emissions from energy use in the Slovak Republic, Finland and Sweden (excluding biomass from the calculation reduces this to 51% in Finland and 45% in Sweden). This range reflects country differences in the contribution of the industry sector to economic output, but also differences in the fuels used by industry. For example, in Luxembourg the industry sector accounts for 11% of total GDP while it accounts for 30% in the Slovak Republic (own calculations based on OECD, 2016). The residential and commercial sector contributes between 1% of total energy related emissions in Iceland and 39% in Switzerland. Again, this range reflects differences in the share of the residential and commercial sector in overall economic activity as well as differences in the fuels used by commerce and households. While pricing carbon or increasing the level or coverage of carbon pricing instruments may be unlikely in the short to medium term to alter markedly the weight of the industry or commercial and residential sector in the overall economy of the 41 countries, energy users in these sectors will be encouraged to lower emissions by switching to cleaner fuels and reducing energy use.

Carbon emissions from energy used in electricity generation range from close to zero in Iceland, Switzerland, Norway and Luxembourg to 40% of domestic emissions and well above in Korea, South Africa, Australia, Greece and Israel. With the exception of Luxembourg, which imports a large share of its electricity use from neighbouring countries, all other countries with a share of carbon emissions from electricity use at close to zero generate their electricity mostly from carbon-free, mostly renewable, energy sources. In contrast, the countries with high shares of carbon emissions from energy use in electricity generation rely heavily on fossil fuels, in particular on coal. In these countries, pricing carbon can be expected to encourage electricity generators to switch from coal to cleaner fuels and thereby lower emissions.

In most countries, the offroad transport sector and the agriculture and fisheries sector contribute substantially less to total carbon emissions from energy use than the previously

Figure 4.3. **The composition of CO_2 emissions from energy use by sector varies widely across countries**



Note: Figure 4.3 sorts countries by their share of CO_2 emissions from the road transport sector in 2012.

Source: OECD calculations based on OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, http://dx.doi.org/10.1787/9789264232334-en, and IEA (2016), "Extended world energy balances", *IEA World Energy Statistics and Balances* (database), http://dx.doi.org/10.1787/data-00513-en.

discussed sectors (c.f. Table 4.3 in the subsection on ”Effective carbon rates within the non-road sectors”). Nevertheless, carbon emissions from offroad transport are a more substantial share of the total in some countries, with e.g. 9% of total emissions in Norway and about 5% in the United States, Canada and Russia. Whereas CO_2 emissions from energy use in pipelines are mainly responsible for this large share in Russia, domestic aviation and navigation are the main contributors in the United States and Norway respectively. With the exception of Iceland, emissions from agriculture and fisheries are at about 5% of total emissions or below. While emissions from these sectors tend to be relatively low, some of the sectors, such as air transport, may in the future contribute a substantially larger share, especially if no measures are undertaken to limit their emissions.

Effective carbon rates: Results of the analysis

A complete picture of how countries use market-based instruments to price CO_2 emissions requires evaluating all three components of the effective carbon rate (ECR) together, i.e. carbon taxes, specific taxes on energy use and tradable emission permit prices. Also, when evaluating ECRs, it is crucial to consider both the rate and the share of emissions facing a price (the latter being called ECR coverage in the remainder). This section presents detailed results of the analysis of ECRs both across countries as a whole and for individual countries, and discusses how the individual instruments contribute to the overall level and coverage of carbon prices.

Effective carbon rates – overview and country results

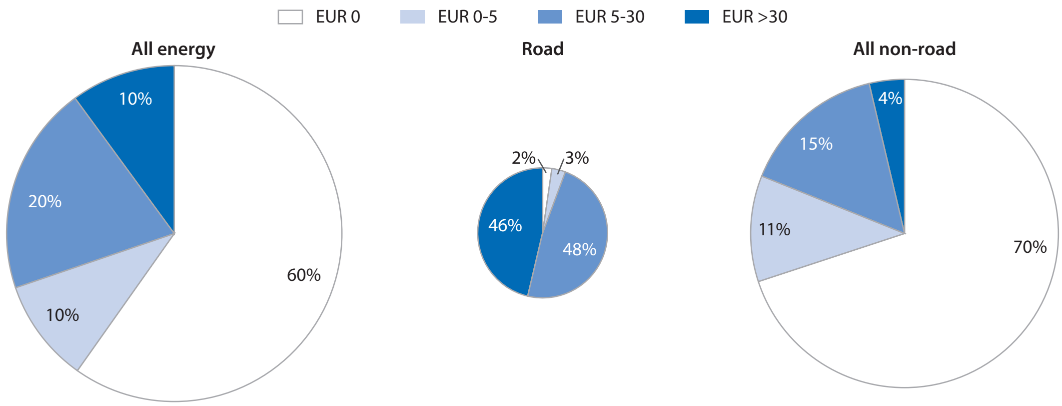
This subsection provides an overview of the ECRs for the group of countries as a whole and of ECRs at the economy-wide level for each individual country. Due to the differences between road and other sectors, ECR levels and coverage are presented separately for CO_2 emissions from road transport (road) and for those from all sectors other than road transport (all non-road sectors), including offroad transport, industry, agriculture and fishing, residential and commercial, and electricity.

ECRs across OECD and selected partner economies

Across the 41 OECD and selected partner economies, 60% of all CO_2 emissions from energy use do not face a carbon price from market-based instruments: the ECR is zero. Where CO_2 emissions are priced, the price is generally very low: 90% of all emissions face an ECR below EUR 30 per tonne of CO_2, the lower-end estimate of the climate cost of carbon used here. Prices on emissions from sectors other than road transport – “non-road sectors”, responsible for 85% of total CO_2 emissions in the 41 countries – are particularly low. In road transport, nearly all emissions have a positive and relatively high ECR because of high specific taxes on energy use in this sector. Specific taxes on energy use provide the main price signal, both in terms of the level of ECRs and in terms of the proportion of emissions facing an ECR larger than zero, even outside the road sector. Carbon taxes and tradable emission permit prices currently constitute only a small share of ECRs. These patterns hold both across the 41 economies and within most individual countries.

Figure 4.4 summarises the ECRs that apply to all CO_2 emissions from energy use across the 41 countries. The information is presented by ECR intervals, showing the share of emissions that are not priced, and the shares of emissions with an ECR between EUR 0 and EUR 5, between EUR 5 and EUR 30, and above EUR 30 per tonne of CO_2. The left panel relates to all CO_2 emissions from energy use in the 41 countries, the middle panel shows emissions in the road transport sector, and the right panel shows emissions from all non-road sectors.

Figure 4.4. **Proportion of CO_2 emissions from energy use at different ECR intervals**



Note: The size of each pie chart corresponds to the amount of CO_2 emissions in the respective sector: all energy (100%), road transport (15%), and all non-road sectors (85%).

Considering total energy use in the 41 countries (left panel of Figure 4.4), 60% of CO_2 emissions are not priced at all, 10% are subject to an ECR between EUR 0 and EUR 5 per tonne of CO_2, 20% to an ECR between EUR 5 and EUR 30 per tonne of CO_2, and 10% to an ECR above EUR 30 per tonne of CO_2. Hence, 90% of total CO_2 emissions from energy use in the 41 countries are priced below the lower-end estimate of the climate cost of carbon. 70% of total CO_2 emissions are priced at a level of less than EUR 5 per tonne of CO_2, implying that there is only a very small policy-driven price incentive to reduce CO_2 emissions.

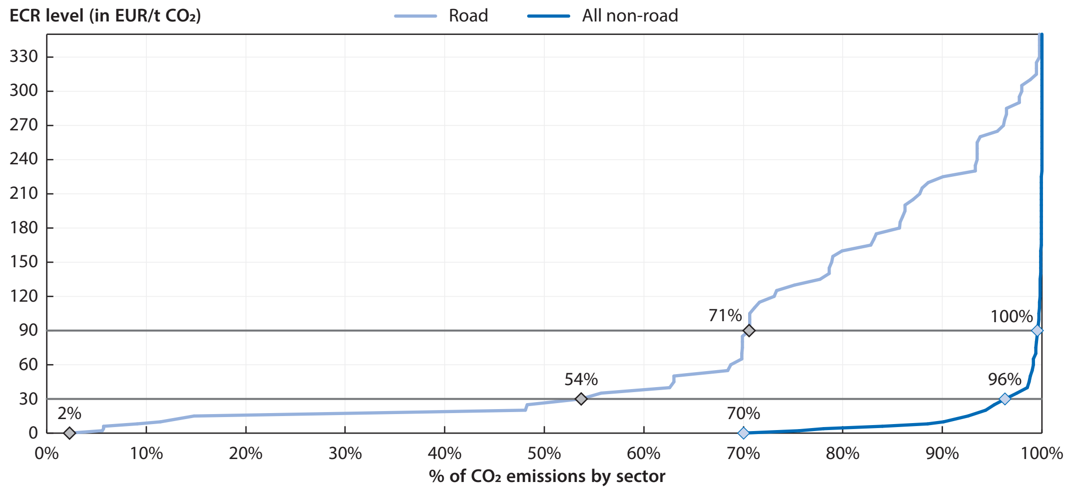
Economy-wide ECRs hide considerable differences between road and non-road sectors. In road transport (middle panel of Figure 4.4), only 2% of CO_2 emissions are not priced at all and 46% face an ECR above EUR 30 per tonne of CO_2. Excluding emissions from road transport (right panel of Figure 4.4), 70% of CO_2 emissions are not priced at all and only 4% face an ECR above EUR 30 per tonne of CO_2. The relatively high ECR in road transport is a result of specific taxes on energy use (i.e. excise taxes on gasoline and diesel) that are applied at comparatively high rates in each of the 41 countries – with few exceptions, the emissions trading systems included in this report do not cover emissions from road transport.

Looking at the full distribution of ECRs confirms that emissions in the road sector are priced significantly more strongly than emissions in the non-road sectors (Figure 4.5). Figure 4.5 sorts CO_2 emissions from energy use according to the ECR at which they are priced, starting at zero. The horizontal axis shows the proportion of CO_2 emissions in the road or non-road sectors and the vertical axis shows the corresponding ECR (in EUR per tonne of CO_2).

The share of emissions priced at any given ECR in the road and non-road sectors can be read from Figure 4.5. For example, 54% or road transport emissions are priced at less than EUR 30 per tonne of CO_2, and 96% of non-road emissions. Also shown, 71% of road transport emissions face an effective carbon rate below EUR 90 per tonne of CO_2 while

100% of non-road emissions are priced below that level. The light blue price line, for road emissions, is very steep once the line at EUR 30 is crossed, indicating that a larger part of emissions is priced at much higher levels than EUR 30 per tonne of CO_2 than is the case for non-road emissions (dark blue line).

Figure 4.5. **Proportion of CO_2 emissions from energy use subject to different levels of effective carbon rates (biomass emissions included)**



For road transport, specific taxes on energy use (namely excise taxes on gasoline and diesel) provide an incentive to reduce fuel consumption, and therefore CO_2 emissions, even though they may not have been introduced with the direct intention of abating such emissions. The higher rates on emissions in the road sector may be explained by the broader range of policy goals that governments often seek to address when taxing transport fuels. Firstly, energy use in road transport has a number of other negative external costs, such as local air pollution, congestion, accidents and noise. Countries may therefore tax transport fuels to make energy users consider these external costs in their transport choices, even though some of these are only very indirectly linked to fuel use and may be more effectively addressed by driving-based charges. Secondly, countries often tax transport fuels to raise revenue for the general budget or specifically to fund road infrastructure.

ECRs by country

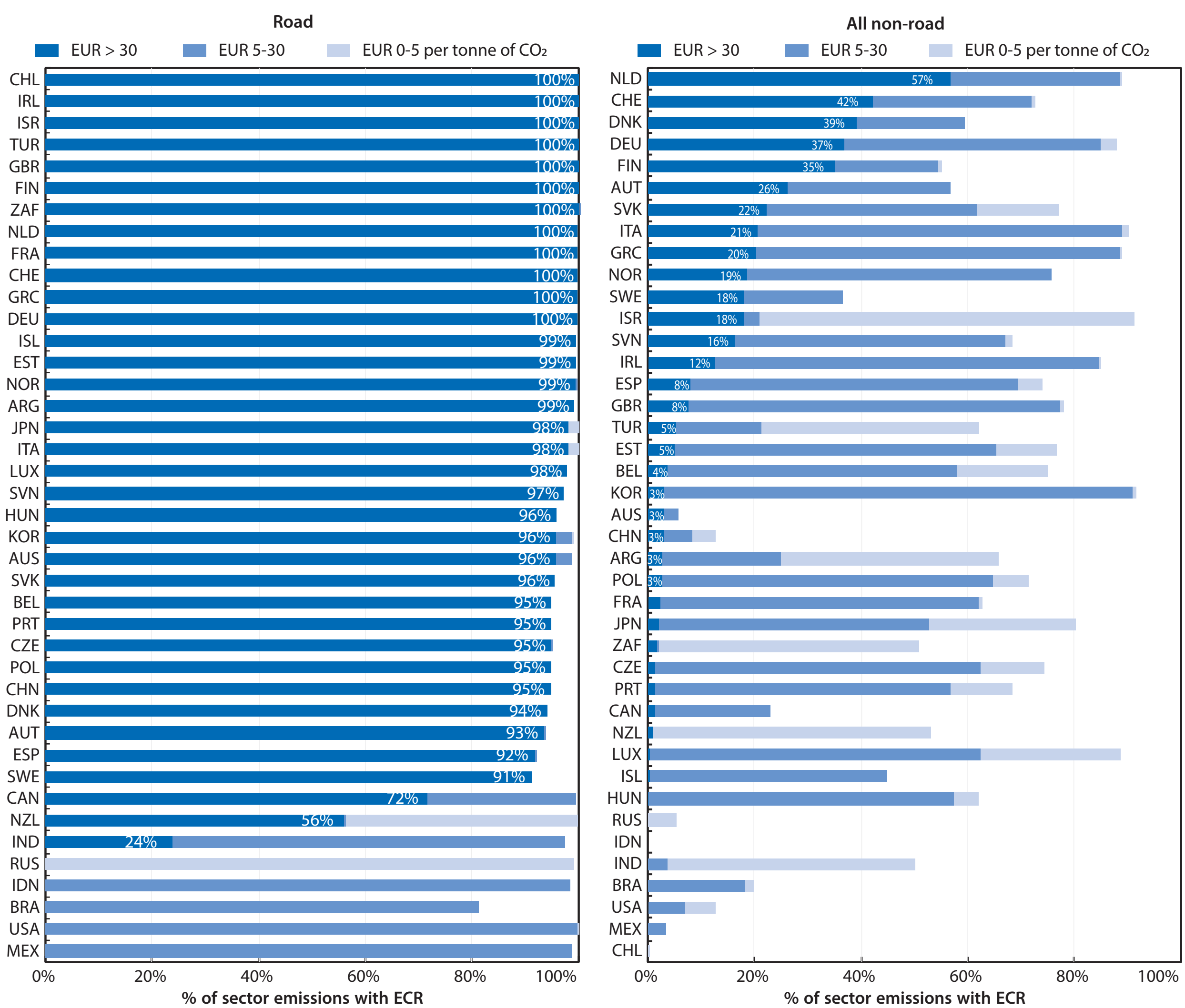
ECRs vary strongly within and across countries, but there are similarities too. The higher ECRs observed in road transport, relative to non-road sectors, at the level of the 41 countries are also identified when looking at countries individually. Almost all CO_2 emissions from road transport energy are priced at or above EUR 30 in most countries, whereas emissions from energy use in non-road sectors rarely face an effective carbon rate above EUR 30 per tonne of CO_2. Further, a significant share of non-road emissions are not priced in many countries: twenty-one countries, for instance, do not apply any price to more than two-thirds of emissions from non-road sectors.

Figure 4.6 shows countries' CO_2 emissions from energy use by ECR interval, using the same ECR intervals as in Figure 4.4 and also distinguishing between emissions in road transport (left panel) and in all non-road sectors (right panel). In 2012, thirty-three countries priced at least 90% of road transport emissions at or above EUR 30 per tonne of CO_2 and only Brazil, Indonesia, Mexico (which has significantly increased road transport fuel taxes since), Russia and the United States priced all road transport emissions below EUR 30 per tonne of CO_2. For emissions in the non-road sectors, only the Netherlands priced more than 50% of emissions at or above EUR 30 per tonne of CO_2, and 40 countries priced less than 50% of non-road emissions at EUR 30 or more (of which seven priced no emissions from non-road at EUR 30, namely Brazil, Chile, India, Indonesia, Mexico, Russia and the United States). In the road sector, almost all emissions faced an ECR greater than zero, ranging from 81% of emissions in Brazil to nearly 100% coverage in 22 countries. In the non-road sector, the proportion of emissions covered by an ECR of greater than zero ranged from 0% in Chile and Indonesia to just over 90% in Italy, Israel and Korea.

A carbon price of at least EUR 30 per tonne of CO_2 covering all emissions in each sector would ensure that incentives for CO_2 emission abatement were consistent with the lower-end estimate of the climate cost of carbon. Lower prices may be a useful first step toward this goal, generating revenue and providing some incentive for abatement. To consider lower ECR levels, Figure 4.6 also shows the share of emissions priced at an ECR of EUR 5 per tonne of CO_2 or greater. Almost all CO_2 emissions in road transport are subject to an ECR

Figure 4.6. **Proportion of CO_2 emissions at different ECR intervals by country (biomass emissions included)**

The composition of effective carbon rates



of above EUR 5 per tonne of CO_2, indicating that there is some policy-driven incentive for emissions reductions. In non-road sectors, the proportion of emissions priced at EUR 5 per tonne of CO_2 varies strongly between countries. Some countries do not price any non-road emissions at or above EUR 5 per tonne of CO_2 (Chile, Indonesia, and Russia), while twenty-four countries price at least 50% of non-road CO_2 emissions at or above this level.

The three market-based instruments used to price CO_2 emissions from energy use are employed in different ways across countries, applying to different (and sometimes overlapping) emission bases, and at widely varying rates. This section describes the contribution of each component (carbon taxes, specific taxes on energy use and tradable emission permit prices) to the levels and coverage of the ECRs observed in the 41 countries, distinguishing between road transport and the non-road sectors.

Average rates of ECR components

The average rate of each of the three ECR components is a summary measure that combines information on the rates and coverage of each price instrument. Average rates are weighted by the share of CO_2 emissions covered at each rate by each instrument. CO_2 emissions that do not face a price are therefore included in the denominator but not in the numerator used to calculate the averages.[1] Average rates show how much emitters pay on average to emit one tonne of CO_2 in a country or sector, and are a summary measure of the distribution of ECR components. The average rates of the three components can be combined into an average ECR.

Average rates for each component, and average ECRs, should be interpreted with caution, as they do not provide any information on the shape of the underlying distribution of rates. For example, an average ECR of EUR 25 per tonne of CO_2 could arise where a small share of the emissions is priced well above this level but with the majority of emissions priced far below it. An average ECR is thus no indicator of the amount of emissions that is priced above or below the average rate. Nevertheless, the average rates allow for quick inter-country comparison of the overall use of the components of ECRs.

Table 4.1 sets out the average rates for specific taxes on energy use, carbon taxes and emissions trading permits across the 41 countries as a whole, differentiating between the road and non-road sectors. With average rates of EUR 72.31 and EUR 3.05 per tonne of CO_2, respectively, specific taxes on energy use are the dominant component in both road transport and all non-road sectors. Carbon taxes and tradable emissions permit prices contribute less to average ECRs, at less than EUR 1 per tonne of CO_2 in both road and non-road sectors. Tradable emissions permit prices are more significant in the non-road sectors than in road transport, although at a relatively low average rate of EUR 0.87 per tonne of CO_2. The average ECRs on all CO_2 emissions from energy use are relatively low (as shown in the bottom line of Table 4.1) due to the low share of road emissions in total emissions: road transport accounts

Table 4.1. **Average rates by ECR component (in EUR per tonne of CO_2) (biomass emissions included)**

	(1) Specific taxes	(2) Carbon tax	(3) ETS	(4) = (1) + (2) + (3) Average ECR
Road transport	72.31	0.87	0.44	73.61
All non-road sectors	3.05	0.08	0.87	4.00
All sectors	13.44	0.19	0.81	14.44

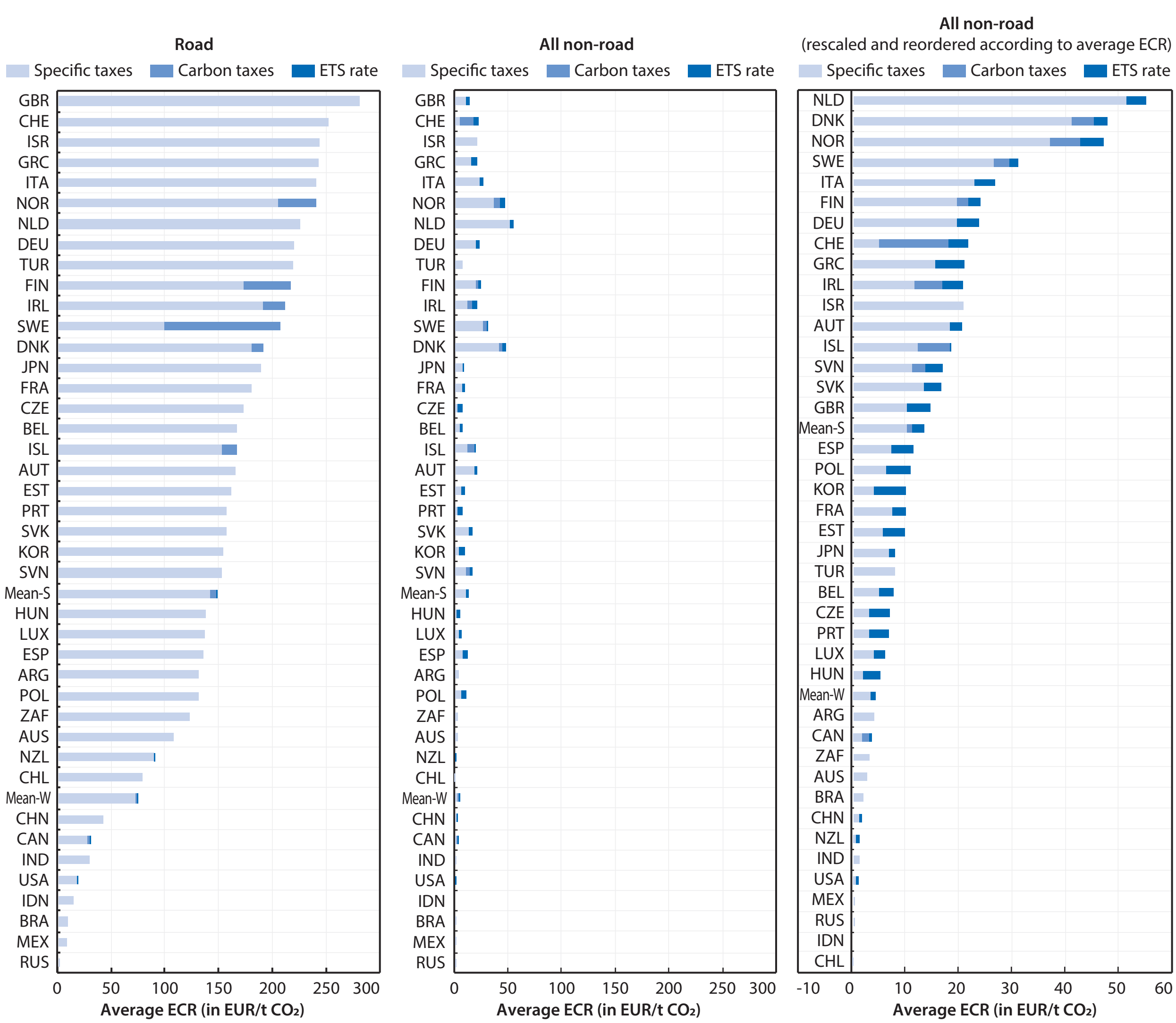
for 15% of total CO_2 emissions from energy use in the 41 countries, giving road emissions a low weight in the average rates across all sectors.

A similar dominance of the specific tax component on energy use is seen within most of the 41 countries, although there is considerable variation in the level of average ECRs in each country and in the way the different price instruments are applied.

Figure 4.7 presents average ECRs in each country, disaggregated into the three price instruments, showing both emissions in road transport (left panel) and in non-road sectors (middle and right panel; note the difference in scale of the horizontal axis between the left- and rightmost panels). In road transport, specific taxes on energy use are by far the price instrument with the highest average rate in all countries except Sweden. Carbon taxes play a role in pricing road emissions only in the Nordic countries (Sweden, Norway, Finland, Denmark and Iceland) and in Ireland.

The high contribution of carbon taxes to average ECRs in road transport in Sweden is due to a relatively high general level of carbon pricing and also to the fact that the introduction of the Swedish carbon tax was accompanied by a commensurate reduction in

Figure 4.7. **Average effective carbon rates by country and price instrument (biomass emissions included)**



excise taxes. A similar approach was recently followed in France in 2014 (not reflected in the data shown in this report), where the excise tax rate for gasoline was reduced in parallel to the introduction of a carbon tax, although future increases in the carbon tax rate will not be accompanied by excise reductions. The cases of Sweden and France demonstrate that an understanding of carbon pricing requires consideration of all market-based instruments: considering one ECR component in isolation can give a misleading picture of how countries price CO_2 emissions if there are large differences in other components. Furthermore, considering policy change also requires looking at the three components, as an increase in one component can be accompanied by a reduction in another.

The average ECR on road transport emissions is above EUR 50 per tonne of CO_2 in all countries except China, Canada, India, the United States, Indonesia, Brazil, Mexico and Russia. The simple average ECR on road transport emissions across countries is above EUR 150, and is much higher than the weighted country average of less than EUR 100, indicating that some countries with high levels of CO_2 emissions have relatively low average ECRs in road transport.

The average ECR on emissions from non-road sectors (middle and right panels of Figure 4.7) is above EUR 30 per tonne of CO_2 in just four countries – Sweden, Norway and Denmark, and the Netherlands (the only country with a rate above EUR 50). Average ECRs on non-road emissions are above EUR 20 in seven other European countries (Austria, Ireland, Greece, Switzerland, Germany, Finland and Italy) and Israel. The other countries price non-road emissions at very low levels, in some cases applying a price close to zero.

The composition of ECRs is much more diverse in non-road sectors than in road transport. In non-road sectors, specific taxes on energy use are deployed to a much lesser extent than in road transport. Carbon taxes and tradable emission permit prices contribute more strongly to average ECRs in the non-road sectors, particularly in countries that historically apply specific taxes on energy use to a limited extent. For example, tradable emission permit prices make up more than 40% of the average ECR in non-road sectors in the Czech Republic, Estonia, Hungary, Korea, New Zealand, Poland, Portugal and the United States (even if the latter has no country-wide trading system). Carbon taxes represent more than 40% of the average non-road ECR in Switzerland, where they cover most residential and commercial emissions, and in Canada, where British Columbia's carbon tax applies at a relatively high rate (covering 9% of Canadian non-road emissions). Here too, the simple country average ECR is well above the weighted country average ECR. Low ECRs on non-road transport emissions suggest a potentially significant role for the carbon tax and emissions trading components of ECRs in pulling up average rates, in line with policy dynamics pointing towards an increased use of these explicit carbon pricing mechanisms.

Coverage of ECR components

A different way of considering the contribution of each price instrument to ECRs is to consider the share of emissions from energy use subject to each instrument, i.e. the coverage of each instrument. The coverage of the three instruments may overlap, so that the overall proportion of emissions covered by an ECR is often lower than the sum of the emissions covered by each of the three individual components. For example, an excise tax may apply to the same sector as a carbon tax; or an excise tax and an emissions trading system may apply to the same industry.

Table 4.2 presents the share of CO_2 emissions from energy use subject to each price instrument. It also shows the combined coverage of both tax instruments. The combined coverage of all three instruments is reported in the last column showing the proportion of emissions in each sector that face a positive ECR. As stated in the first section of this chapter, while 98% of road transport emissions are priced at a positive effective carbon rate, only 30% of emissions in other sectors are. Across all emissions from energy use only 40% are subject to a positive effective carbon rate.

Table 4.2. **Proportion of emissions from energy use subject to a positive effective carbon rate by price instrument (biomass emissions included)**

		Taxes			
	ETS	Carbon tax	Specific taxes	Combined tax	ECR
Road	5%	2%	98%	98%	98%
All non-road	13%	0%	23%	23%	30%
All	12%	1%	34%	34%	40%

Overall, carbon taxes are the smallest component of ECRs, followed by ETS prices. Specific taxes on energy use are much higher than both carbon taxes and ETS prices. The high ECR coverage in road transport is nearly entirely driven by the high coverage of specific taxes on energy use (98%), but the breakdown of coverage by price instruments in non-road sectors shows a different pattern, with specific taxes on energy use covering 23% of CO_2 emissions and tradable emissions permit prices covering 13%.

Price instruments can overlap, so that implementing new carbon pricing instruments does not necessarily increase the overall proportion of CO_2 emissions subject to a price. Where a tax applies to part of the same base as an ETS, this increases the price of emissions, but does not increase the total abatement under the ETS (in the presence of a binding cap), leading to lower permit prices under the ETS. This can reduce cost-effectiveness, as prices are no longer uniform. In Table 4.2, summing the coverage by individual price instruments can produce a number greater than the total sector coverage in the last column. For example, in road transport, across the 41 countries, nearly all emissions covered by an ETS are also subject to a specific tax on energy use. Similarly, carbon taxes and specific taxes on energy use often cover the same emissions in both the road and non-road sectors. The effect of carbon taxes on increasing coverage is therefore small. However, in non-road sectors, emissions trading systems more strongly contribute to total coverage. Taxes cover 23% of emissions, and this increases to 30% if trading systems are accounted for (an increase by 30%). Since emissions trading systems cover 13% emissions, there is a significant overlap between taxes and trading systems, as is discussed in more detail below and in Annex A.

Effective carbon rates within the non-road sectors

Emissions from non-road sectors account for 85% of total CO_2 emissions from energy use in the 41 OECD and selected partner economies. As seen above, they are less frequently subject to an ECR, and, on average, are subject to lower ECRs than road transport emissions. This section analyses the different non-road sectors in more detail. The non-road sectors include offroad transport, industry, agriculture and fishing, residential and commercial energy use, and the electricity sector. Of these, energy use in industry, electricity and in the residential and commercial sector gives rise to the largest proportion of carbon emissions (roughly 33% in the case of industry and electricity, and 15% in the case of the residential and commercial sector). Table 4.3 the share of CO_2 emissions from energy use from the different sectors.

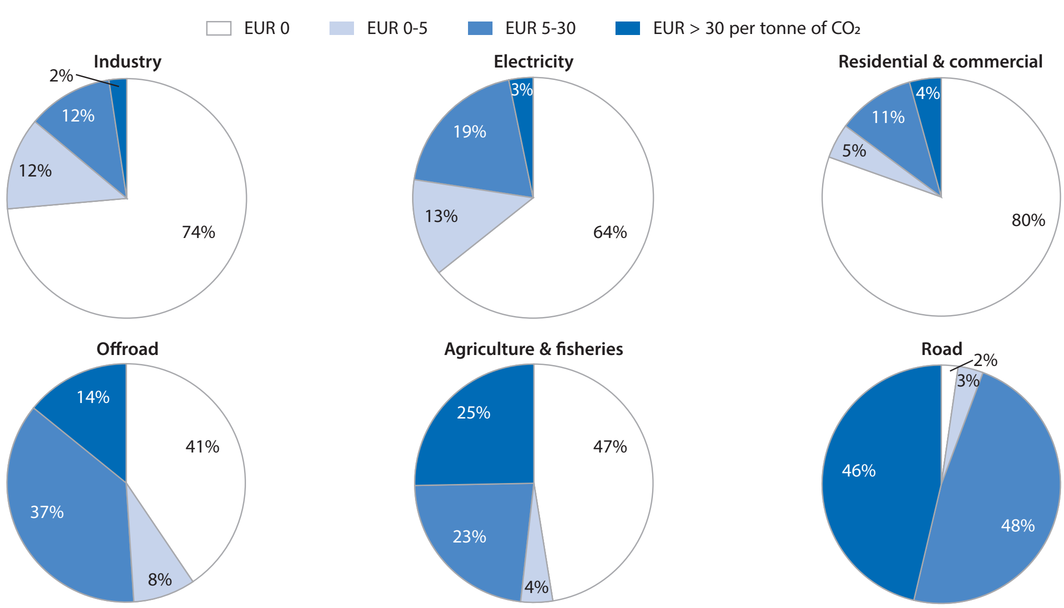
Table 4.3. **Categorisation of CO_2 emissions from energy use**

	Sector	CO_2 emissions included in sector	Proportion of economy-wide CO_2 emissions in all countries on average
	Road	All CO_2 emissions from energy used in road transport.	15.0%
Non-road sectors	Offroad	All CO_2 emissions from energy used in non-road transport (incl. pipelines, rail transport, domestic aviation and maritime transport).	2.2%
	Industry	All CO_2 emissions from energy used in industrial processes, in heating (incl. inside industrial installations) and in the transformation of energy, including fuels used for auto-generation of electricity in industrial installations.	33.3%
	Agriculture & fisheries	CO_2 emissions from energy used in agriculture, fisheries and forestry. CO_2 emissions from energy used in on-road transport are included in the road sector.	1.2%
	Residential & commercial	All CO_2 emissions from energy used for commercial and residential heating, including fuels used for auto-generation of electricity.	15.1%
	Electricity	All CO_2 emissions from energy used to generate electricity for domestic use excluding fuels used in the auto-generation of electricity.	33.2%

Non-road sector ECRs across OECD and selected partner economies

The proportions of emissions priced at different ECR intervals are broadly similar for the industrial, the electricity and the residential and commercial sectors when looking at the 41 OECD and selected partner economies as a group. As shown in the first row of Figure 4.8, the majority of emissions in each of these sectors (74% in the industry sector, 64% in the electricity sector and 80% in the residential and commercial sector) do not face a price and only a very small proportion is priced above EUR 30 per tonne of CO_2 (2%, 3% and 4% respectively). Between 5% and 13% of CO_2 emissions in these sectors are subject to an effective carbon rate between EUR 0 and EUR 5 per tonne of CO_2 and 11% to 19% to an effective carbon rate between EUR 5 and EUR 30 per tonne of CO_2.

Figure 4.8. **Proportion of CO_2 emissions subject to different ECR intervals by sector (biomass emissions included)**



The shares of emissions within these same ECR intervals in offroad transport and in agriculture and fishing are similar (first and second panel in the second row of Figure 4.8). Compared to the other non-road sectors, a relatively high proportion of emissions from offroad transport and agriculture and fishing is priced, and prices are higher on average. Specifically, 41% and 47% of emissions in these sectors do not face a carbon price, 8% and 4% face a price between EUR 0 and EUR 5 per tonne of CO_2, 37% and 23% face a price between EUR 5 and EUR 30 per tonne of CO_2, and 14% and 25% face a price above EUR 30 per tonne of CO_2. For completeness, Figure 4.8 also shows the results for road transport, which have been described in previous sections.

Although exemptions and reduced rates are often applied to fuel use in non-road transport and in agriculture and fisheries (e.g. to fuel use in agriculture, or in rail transport), the rate structure at which these two sectors are taxed is more akin to the specific energy taxes applied on road use. The higher specific taxes on motor fuels for road use are often used as benchmark rates for the definition of the reduced rates (OECD 2015, 2013). In addition, energy use in these two sectors is dominated by oil products, which are often taxed at relatively high rates compared to coal or natural gas. Neither of the two sectors accounts for more than 2% of overall emissions across the 41 countries on average (Table 4.3), diminishing their weight in the analysis of ECRs. Given the very small proportion of emissions in these two sectors, the presentation and analysis of ECRs will from here focus on the ECRs applied to the remaining non-road sectors, which together comprise 81% of total emissions.

Non-road sector ECRs by country

Table 4.4 allows a closer examination of the pricing patterns of CO_2 emissions in the industrial, the electricity and the residential and commercial sectors (shown in the first row of Figure 4.8). These sectors account for the largest share of emissions on average in each country. The table shows for each country both the proportion of CO_2 emissions from energy use priced at a positive ECR or above EUR 30 per tonne of CO_2 in these sectors.

Patterns of ECR coverage and levels across the industrial sector and the residential and commercial sector are similar within the 41 economies: most countries price only a small proportion of emissions in these sectors at an ECR above EUR 30 per tonne of CO_2 and many countries do not at apply an ECR above EUR 30 to any emissions in these sectors. When looking at countries individually, some differences appear between both sectors. For example, Denmark, Italy, Israel, the Netherlands and Switzerland price a much higher proportion of emissions above EUR 30 per tonne of CO_2 in the residential and commercial sector than in the industry sector. Conversely, in Estonia, Hungary, Indonesia, Norway, Poland, Spain and the United Kingdom, a much larger share of emissions is subject to a positive effective carbon rate in industry than in the residential and commercial sector.

Countries that impose lower ECRs on industrial use, may be seeking to address competitiveness concerns, whereas countries that impose lower rates on the residential sector may place greater weight on concerns regarding the ability of low-income families to afford heating fuels. The lower rates may also be a result of different historical reasons for the imposition of taxes or trading systems on energy used in each sector. Regardless, where lower rates are intended to address competitiveness or distributional concerns, OECD work discussed in Chapter 2 has highlighted that the impact of pricing instruments on both of these factors is often overstated, and that it is generally preferable and possible to find ways to assist these sectors or households that do not weaken the price signal from energy pricing instruments.

Table 4.4. **Proportion of CO_2 emissions priced above EUR 0 and EUR 30 per tonne of CO_2 by country (biomass emissions included), percentages**

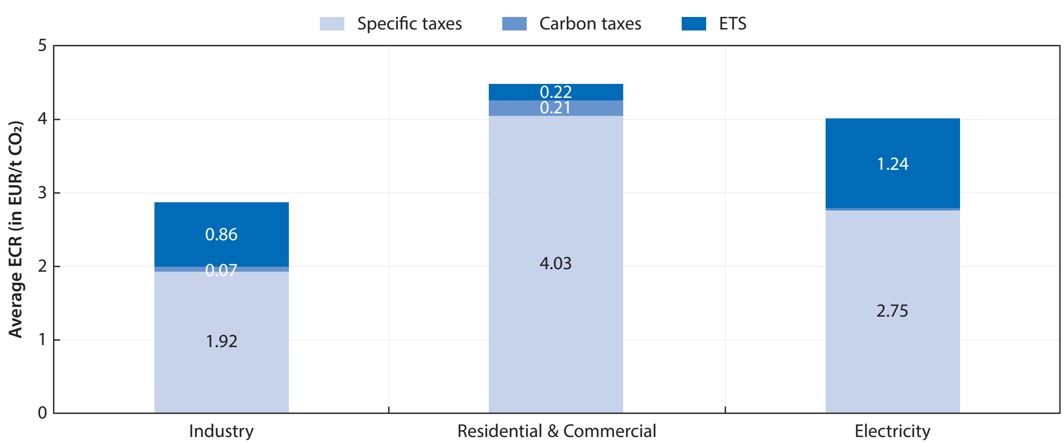
	Industry: Proportion of emissions priced at or above		**Electricity**: Proportion of emissions priced at or above		**Residential & commercial**: Proportion of emissions priced at or above	
	EUR 0	**EUR 30**	**EUR 0**	**EUR 30**	**EUR 0**	**EUR 30**
AUS	8	8	0	0	14	9
AUT	53	21	100	64	50	23
BEL	66	0	100	18	79	0
CAN	18	1	1	0	27	1
CHL	0	0	0	0	1	0
CZE	71	0	97	0	35	0
DNK	49	13	100	100	43	43
EST	73	4	100	0	16	6
FIN	49	25	100	88	30	30
FRA	78	1	100	15	38	0
DEU	80	11	100	82	80	1
GRC	92	29	100	21	61	9
HUN	78	0	100	0	23	0
ISL	19	0	100	100	26	0
IRL	76	15	96	0	74	21
ITA	88	5	100	0	80	61
ISR	35	5	99	13	87	49
JPN	62	1	93	2	100	0
KOR	92	2	92	0	95	20
LUX	80	0	100	0	95	0
MEX	4	0	1	0	1	0
NLD	77	32	100	100	95	59
NZL	44	1	54	0	57	3
NOR	84	12	100	100	23	21
POL	76	2	100	0	9	0
PRT	59	0	100	0	27	6
SVK	70	20	100	0	90	31
SVN	79	9	100	0	36	27
ESP	76	3	100	0	25	20
SWE	33	10	100	100	21	21
CHE	64	17	7	7	82	58
TUR	43	3	100	0	29	0
GBR	84	14	100	0	33	10
USA	5	0	8	0	8	0
ARG	59	1	68	0	94	5
BRA	13	0	100	0	0	0
CHN	13	3	13	0	5	4
IND	55	0	81	0	6	0
IDN	0	0	0	0	0	0
RUS	5	0	0	0	8	0
ZAF	8	2	100	0	2	1

In the electricity sector, the majority of countries apply an ECR of greater than zero to a large proportion of CO_2 emissions or even the entire emissions base. Twenty-nine countries price more than 90% of carbon emissions from the industry sector and twenty-two countries price all emissions from the electricity sector (through combinations of emissions trading systems and taxes on electricity use). Only Australia, Chile, Indonesia and Russia, do not price any emissions from electricity generation. The proportion of emissions in the electricity sector subject to an ECR of greater than EUR 30 per tonne of CO_2 differs significantly across countries: eight countries price more than 50% of emissions from the generation of electricity above EUR 30 per tonne of CO_2, while twenty-four countries do not price any of the emissions from the fuels used to generate electricity above EUR 30 per tonne of CO_2.[2]

Impact of different price instruments in the non-road sectors

The impact of different carbon pricing instruments on the level and coverage of ECRs differs among the three non-road sectors analysed. Figure 4.9 presents the average rate for specific taxes on energy use, carbon taxes, and tradable emission permit prices in industry, the residential and commercial sector, and in electricity generation.

Figure 4.9. **Specific taxes dominate ECRs in non-road sectors (biomass emissions included)**



Specific taxes on energy use are the largest component of the average ECR in each of the three non-road sectors shown here. The relative contribution of tradable emissions permits to overall ECRs is relatively large in industry and in electricity. Carbon tax rates are relatively low on average in all sectors under consideration. Average ECRs in the industry and the electricity sector are lower than in the residential and commercial sector, also because of the smaller contribution of excise taxes applying to fuels used by these sectors. The composition of the average ECR in the residential and commercial sector differs from the other two sectors, due to the larger influence of the specific taxes on energy use. The ECR component made up by tradable emissions permits is smaller in the residential and commercial sector, since ETS tend to cover mostly larger firms.

Average ECRs provide a first comparison of the relative importance of the different price instruments, combining both rate and coverage information into a single metric. However, they do not directly show the proportion of emissions covered by each instrument. Table 4.5 supplements the information shown in Figure 4.9 by reporting the share of CO_2 emissions covered by each instrument at a positive rate, as well as the combined total tax coverage. The combined coverage of all three instruments in the last column shows the proportion of emissions in each sector that is subject to an ECR.

Table 4.5. **Proportion of emissions subject to a positive effective carbon rate by price instrument (biomass emissions included)**

		Taxes			
	ETS	Carbon tax	Specific taxes	Combined tax	ECR
Industry	13%	0%	17%	17%	26%
Residential & commercial	3%	1%	17%	18%	20%
Electricity	18%	0%	27%	27%	36%

Of the three large non-road sectors analysed here, ECRs cover a maximum of 36% of emissions in the electricity sector, and lower shares in the industrial (26%) and the residential and commercial sector (20%). In the industrial and electricity sectors, emissions trading systems are much more influential in terms of their coverage, at 13% and 18% respectively, whereas specific taxes on energy use are less important in terms of coverage at 17% of CO_2 emissions in industry and 27% in electricity. The overlap between emissions trading systems and taxes is larger in electricity than in industry (it is smaller in residential and commercial use, because of the small coverage of trading systems). Carbon tax coverage is low in both sectors, and overlaps with the coverage of specific energy taxes, implying that the contribution of this instrument to ECR coverage is not very large.

Starting from a situation in which taxes are already in place – which has been the case in many of the countries analysed – the introduction of emissions trading systems has increased the proportion of emissions that are priced, although not in a one-to-one relation. This is because price instruments often overlap, so that implementing new carbon pricing instruments does not necessarily increase the total coverage of ECRs. Table 4.5 shows that carbon pricing instruments in non-road sectors overlap, although not entirely. For example, in the industry sector 17% of emissions are subject to a specific tax on energy use and 13% to a tradable emission permit price, whereas 26% are subject to an effective carbon rate across the 41 countries. Consequently, 4% of emissions are subject to both a specific tax and an emissions trading system.

Carbon pricing instruments in the industrial and electricity sectors

The importance of carbon pricing instruments in determining ECRs varies between sectors, as seen in the previous subsection. While specific taxes on energy use are the most influential in constituting ECRs in all sectors, emissions trading systems are of particular relevance to the pricing of carbon emissions in the industrial and electricity sectors. Almost all of the emissions trading systems apply most strongly, in terms of the emissions subject to the system, to these two sectors. Of the six sectors analysed here, the industry and electricity sector are also the largest in the share of CO_2 emissions from energy use, each at just over 33% each for the 41 economies as a whole.

In the industry sector, emissions trading systems apply to 13% of CO_2 emissions from energy use across the 41 countries, as shown in Table 4.5. This relatively high coverage (compared to the extent to which emissions trading systems apply in most other sectors) causes the comparatively greater influence of emissions trading systems in determining average ECRs in the industrial sector, as shown in Figure 4.9 (though the contribution of specific taxes on energy use to ECRs remains higher).

Within the 41 countries, the influence of emissions trading systems in determining ECRs varies. Twelve of the countries considered do not have an emissions trading system. In the countries which price emissions via tradable permits, the coverage of emissions trading systems in the industrial sector varies from over 90% in Greece and Korea to 1% in Luxembourg and 5% in China. By way of contrast, taxes (including both specific taxes on energy use and carbon taxes) apply to industrial emissions in all countries except Chile, Indonesia and the United States, covering on average 37% of emissions in the remaining countries. The degree of overlap between the two instruments (i.e. the share of emissions that are subject to both emissions trading systems and taxes) ranges from 9% in Portugal to 57% in Greece.

To highlight the differences in the application of the different price instruments across countries, Figures 4.10 and 4.11 compare the contribution of taxes and emissions trading systems to ECR coverage and average ECRs in the industrial sector in each country. Figure 4.10 shows the proportion of emissions subject to a positive ECR, distinguishing between CO_2 emissions that are covered only by taxes (including carbon taxes and specific taxes on energy use), emissions that are covered only by a tradable emission permit price, and emissions that are covered by both by taxes and emissions trading systems.[3] Figure 4.11 presents average ECRs in the industry sector, disaggregated by price instrument, excluding unpriced emissions. The order of countries is the same in both figures to allow comparison between the proportion of emissions subject to each price instrument and each instrument's average rate in each country.

Figure 4.10. **Proportion of emissions subject to a positive effective carbon rate in the industry sector (biomass emissions included)**

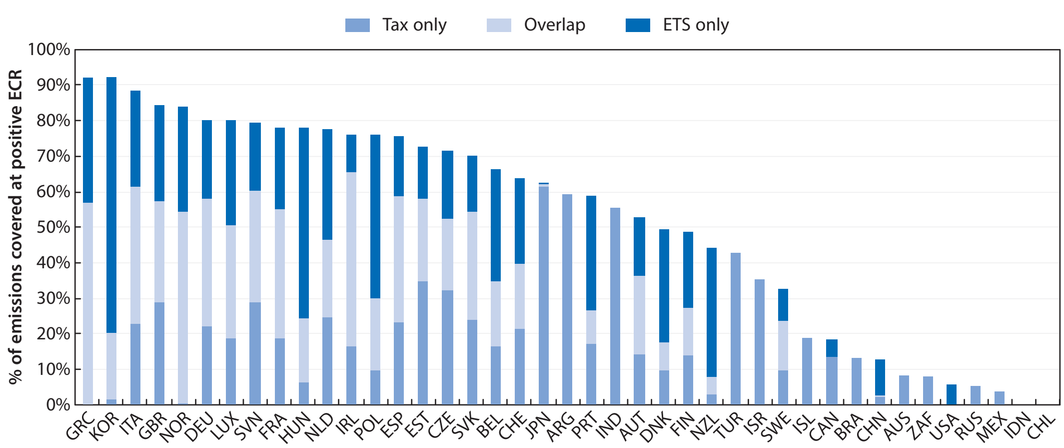
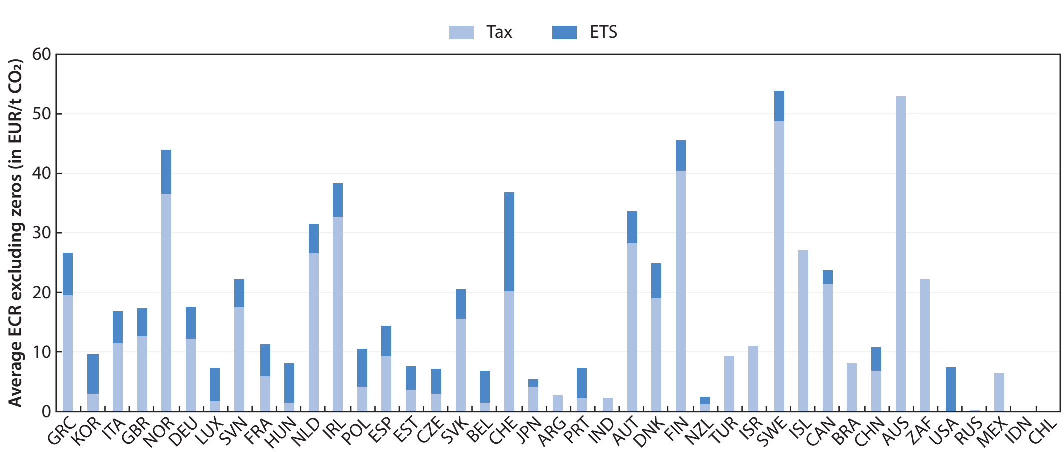


Figure 4.11. **Average effective carbon rates in the industry sector (biomass emissions included)**



Average tax rates on emissions (here excluding zero rates) in the industrial sector are very heterogeneous across countries, ranging from EUR 54 per tonne of CO_2 in Sweden to very low rates in India, New Zealand and Russia and no ECR at all in Chile, Indonesia and the United States.[4] In most countries, taxes on CO_2 emissions from energy use remain the dominant instrument in their contribution to overall ECRs, although in of Belgium, the Czech Republic, Estonia, Hungary, Korea, Luxemburg, Poland, Portugal, and the United States, trading systems dominate. The United States is the only country with the entire average ECR constituted by price signals from emissions trading systems (California and RGGI), whereas in eight countries the ECR consists entirely of taxes on energy use.

Comparison of the proportion of emissions that are subject to a pricing instrument, and the average rates of each instrument, shows that emissions trading systems typically apply at lower rates than taxes on CO_2 emissions from energy use (Figure 4.11). However, in all countries where emissions trading systems apply, they increase the share of emissions covered at a positive rate in the industrial sector beyond those covered by taxes (Figure 4.10).

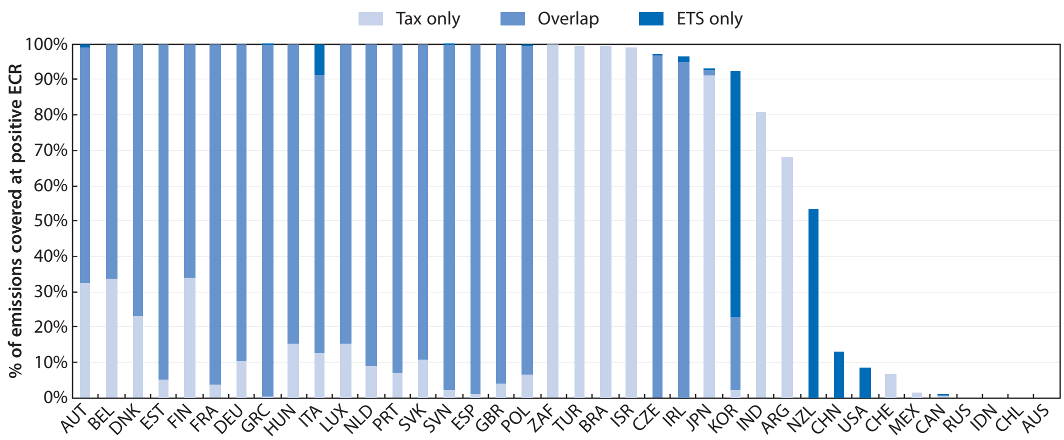
In the electricity sector, emissions trading systems apply to 18% of CO_2 emissions from energy use, as shown in Table 4.5. This is the sector in which emissions trading systems have the greatest coverage, which helps explain the comparatively larger average rate resulting from emissions trading systems in this sector (see Figure 4.9). However, the coverage of emissions trading systems in the electricity sector strongly overlaps with that of specific taxes on energy use, both at an aggregate level and within 22 of the 30 countries in which an ETS is applied. Specific taxes on energy used to generate electricity fail to distinguish between the carbon-intensity of fuels used to generate electricity if they are levied on an energy content basis, but they do raise the price of emission-intensive electricity all the same.

Within each country, CO_2 emissions in the electricity sector are much more likely to be priced than industry emissions. Figures 4.12 and 4.13 show the contribution of taxes and emissions trading systems to ECR coverage and to average carbon rates (excluding zeros) in the electricity sector in each of the 41 countries. As shown in Figure 4.12, the majority of countries price more than 90% of emissions from electricity. In countries where more than 90% of emissions are priced, both taxes and emissions trading systems are widely implemented and largely overlap (except in Brazil, Iceland, Israel, South Africa and Turkey, where no ETS applies). In some countries with low or no tax coverage in certain sectors, emissions trading systems contribute significantly to total coverage. For example, emissions trading systems increase the proportion of emissions subject to an ECR in the electricity sector from 27% to 92% in Korea and from 0% to 54% in New Zealand. In China and the United States, implementation of regional emissions trading systems broadens ECR coverage from 0% to 13% and 8% respectively.

Average ECRs on emissions in the electricity sector are very heterogeneous across countries, as shown in Figure 4.13. As in the industrial sector, emissions trading systems contribute significantly to average carbon rates in countries where tax rates are relatively low or zero, including China, the Czech Republic, Estonia, Hungary, Ireland, Korea, Luxemburg, New Zealand, Poland, Portugal, the Slovak Republic, Spain and the United States.

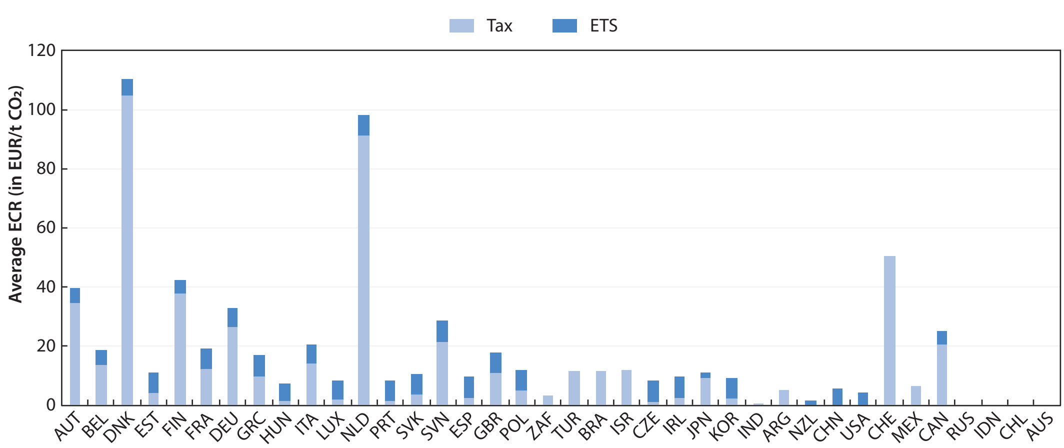
Figures 4.10 through 4.13 demonstrate that the different carbon pricing instruments do not only affect carbon price levels but also have strong effects on the proportion of emissions subject to a price. A comprehensive evaluation of pricing instruments hence requires consideration of both the rates and coverage of each instrument.

Figure 4.12. **Proportion of emissions subject to a positive effective carbon rate in the electricity sector (biomass emissions included)**



Note: The graph excludes three outliers – Iceland, Norway and Sweden.

Figure 4.13. **Average effective carbon rates in the electricity sector (biomass emissions included)**



Note: The graph excludes three outliers – Iceland, Norway and Sweden.

Low carbon rates covering a large proportion of emissions may represent a first step towards pricing emissions and to making polluters pay for the climate cost of their emissions. Continued extension of carbon rate coverage to a wider set of emissions in the industry and electricity sectors – responsible together for 66.5% of all CO_2 emissions from energy use in the 41 countries – would strengthen carbon pricing policies. The choice of ECR component will largely depend on the individual circumstances and preferences of policy makers in each country.

Treatment of biomass in the calculations

The analysis of ECRs in the previous sections of this chapter does not differentiate between CO_2 emissions from the combustion of biomass and CO_2 emissions from the combustion of fossil fuels, consistent with the approach taken in previous OECD work

(OECD, 2013 and 2015). Total CO_2 emissions from energy use in each country in the results above hence include emissions from biomass combustion. However, many countries and the design of many emissions trading systems take a different approach to biomass emissions, treating them as carbon neutral on a life cycle basis. Consequently, emissions from biomass at the point of combustion are excluded from (or are zero-rated in) the consideration of CO_2 emissions from energy use in many emissions trading systems.

To capture both approaches to the treatment of biomass, the results in this report have been calculated both inclusive and exclusive of the emissions from biomass. This report takes emissions from biomass to be those from primary solid biofuels, biogases, biogasoline, biodiesel and other liquid biofuels and from municipal waste (renewable and non-renewable). The results in other sections of the report show results with emissions from the combustion of biomass included. In contrast, this section provides a snapshot of how the treatment of biomass affects the calculation of the ECRs presented elsewhere in the report. The differences arise entirely from the alternative approaches taken towards the accounting of emissions from biomass, and are not due to any policy changes. The degree to which there are differences in the results when biomass emissions are excluded from the analysis depends on three elements: firstly, the degree to which biomass is used in the country or sector being considered; secondly, the way in which biomass emissions are priced (either through taxes or through emissions trading systems); and thirdly, the distribution of ECRs on non-biomass emissions in the country or sector considered.

The use and pricing of biomass emissions differs between sectors, as summarised in Table 4.6: 95% of biomass in the 41 countries is used outside the road sector, and 89% of biomass is used in residential heating and industrial processes. Emissions from biomass used in the non-road sectors are typically not subject to a price. Emissions trading systems zero-rate or exclude biomass, and in non-road sectors it is rarely taxed, except indirectly when used to generate electricity (a very small proportion of biomass) via electricity consumption taxes. As a result, 94% of biomass emissions in the non-road sectors have an ECR of zero, and within residential and commercial use, no biomass emissions are priced.

Biomass use in road transport is limited and causes around 5% of total biomass combustion emissions in the 41 countries. Emissions rarely are subject to an emissions trading system, as most systems do not cover the road sector. However, biomass is often taxed at similar rates as other fuels for road use, meaning that the average tax rate on biomass emissions in this sector is above EUR 30 per tonne of CO_2 everywhere except in the United States. Also, the proportion unpriced biomass emissions is smaller in the road sector, at 36% across the 41 countries as a whole (although across countries, 100% being unpriced in 21 countries and all biomass emissions being priced in 11 countries).

Consequently, the impact of excluding biomass emissions from the calculations has different impacts in the road and non-road sectors. In the non-road sectors, excluding biomass emissions removes a sizeable proportion of emissions that are priced at zero, reducing the proportion of emissions with an ECR of 0 from 70% to 66% of total emissions. As few biomass emissions in non-road sectors are priced at a positive ECR, and almost none above EUR 30 per tonne of CO_2, the impacts on ECR coverage at higher rates are primarily due to the distribution of ECRs on non-biomass emissions in the non-road sectors. The overall average ECR in the road sector therefore increases only slightly when biomass is excluded, from EUR 4 to EUR 4.40 per tonne of CO_2.

In the road sector, only 36% of biomass is taxed at zero, and the use of biomass is smaller, so the impact of biomass treatment is smaller. Coverage changes from 2% of total emissions with biomass included to 1% with biomass excluded. Most biomass in the road sector is taxed above EUR 30 (both across and within countries), so that a 2 percentage-point increase in coverage is observed at ECRs between EUR 5 and EUR 30, and this is because the average ECR on biomass emissions in the United States is just under EUR 25 per tonne of CO_2. Excluding biomass emissions from the calculations increases the average ECR in the road sector from EUR 73.61 to EUR 74.45 per tonne of CO_2.

Table 4.6. **Characteristics of CO_2 emissions from biomass**

			Road	All non-road	All emissions
Biomass characteristics	Biomass as % of all emissions		4	13	12
	Unpriced biomass as % of all biomass emissions		36	94	91
	% of biomass used in sector		5	95	100
Coverage (% of total emissions)	ECR 0 (i.e. unpriced)	Biomass included	2	70	60
		Biomass excluded	1	66	56
	ECR 5	Biomass included	94	19	30
		Biomass excluded	96	21	33
	ECR 30	Biomass included	46	4	10
		Biomass excluded	47	4	11
Average ECR (EUR per tonne of CO_2)	Biomass included		73.61	4.00	14.44
	Biomass excluded		74.45	4.40	15.88

Within individual countries, most biomass use occurs in the non-road sectors at low or zero prices. The impact of excluding biomass emissions on ECR levels and coverage for different countries largely depends on the proportion of biomass emissions to total emissions in each country. Countries with a higher proportion of biomass use, particularly outside the road sectors, will see greater responsiveness of ECR results to the treatment of biomass emissions, particularly where other emissions are subject to higher prices. In ten of the 41 countries, more than 20% of total CO_2 emissions are from biomass combustion: Sweden, Finland, Brazil, Indonesia, Chile, Denmark, India, Austria, Portugal, and Estonia. In these ten countries, and in addition in Slovenia, Norway, France, Switzerland and New Zealand, more than 20% of emissions in the non-road sectors is from biomass combustion. In these countries, omitting emissions from biomass combustion leads to significantly higher ECRs. In Sweden, for example, the share of emissions priced at EUR 30 per tonne or more, increases from 34% to 60% if emissions from the combustion of biomass are not included.

Effective carbon rates: The bigger picture

The previous sections investigated ECR levels and coverage in the 41 countries and six sectors, on an aggregate level as well as country-by-country. This section analyses ECRs in a broader context. The "carbon pricing gap" is introduced in the first subsection ("The carbon pricing gap"). The second subsection ("A counterfactual scenario: increase prices and coverage to at least current median levels") uses the carbon pricing gap to simulate counterfactual scenarios, illustrating the impact of different pricing policies on ECR level and coverage. The third subsection ("Effective carbon rates and macroeconomic characteristics") relates the results of the analysis of ECRs to selected broader economic characteristics, i.e. total CO_2 emissions, gross domestic product (GDP), population size and net energy imports.

The "carbon pricing gap"

The extent to which the 41 countries price CO_2 emissions from energy use using market-based instruments can be measured by comparing current prices to the conservative cost estimate of EUR 30 per tonne of CO_2. Specifically, the extent to which emissions are priced at less than EUR 30 per tonne of CO_2 can be seen as the "carbon pricing gap" from market-based policy instruments. This gap here is measured as a percentage. If the ECR on all emissions was at least EUR 30 per tonne, the gap would be zero, and if the ECR was zero throughout, the gap would be 100%.

The indicator is illustrated in Figure 4.14 for the existing ECRs. The dashed line shows the current distribution of ECRs across the 41 economies as a whole. As indicated earlier, 60% of all emissions are not subject to an ECR, and only 10% are subject to an ECR of greater than EUR 30 per tonne of CO_2. The proportion of emissions below the dashed line is subject to a positive ECR. The proportion of emissions between the dashed line and the horizontal line at EUR 30 per tonne of CO_2 (shaded in dark blue in Figure 4.14) is either not priced by any price instrument, or is priced at a level below EUR 30 per tonne of CO_2. The area in dark blue is the carbon pricing gap across the 41 countries, and it equals 80.1%.

Figure 4.14. **The carbon pricing gap, shown in dark blue**

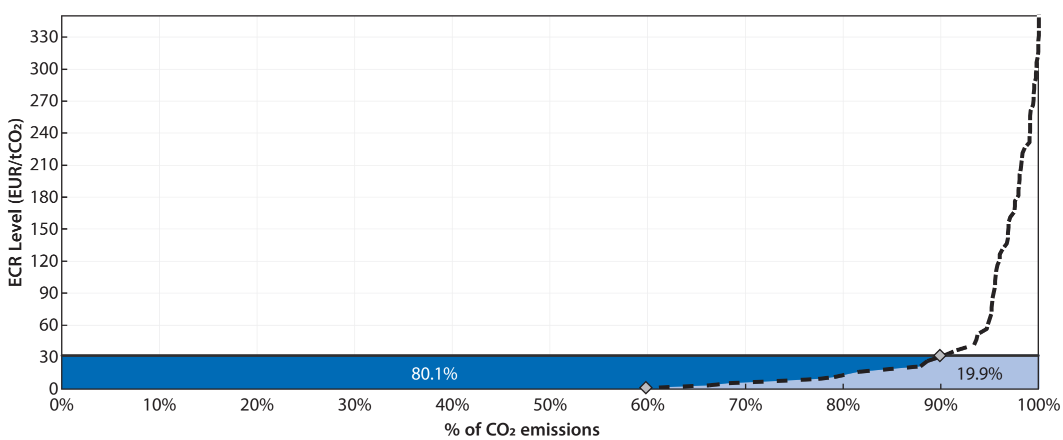
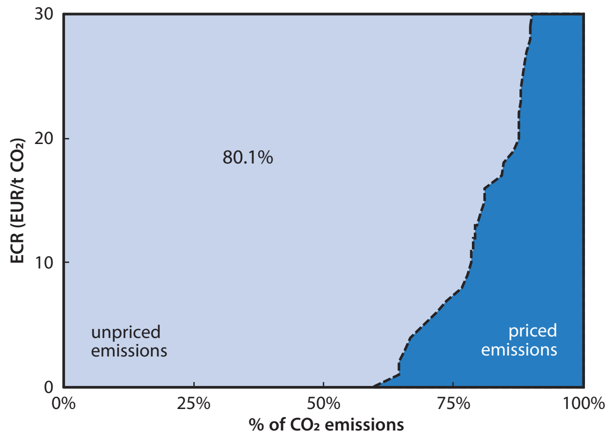


Figure 4.14 can be reshaped to focus solely on the carbon pricing gap, by cutting the vertical axis of the graph at the reference point (EUR 30 per tonne of CO_2), as in Figure 4.15 (which otherwise presents the same information as Figure 4.14). Again, focussing on EUR 30 per tonne of CO_2 does not imply that a carbon price at this level would be sufficient to internalise the climate cost of carbon and nor does it serve as a normative goal.

Figures 4.14 and 4.15 present the results for the group of 41 countries as a whole. From a climate perspective, it is the overall effect of carbon pricing which is important, rather than its location. However, within this group of countries, the individual country carbon pricing gaps are likely to vary substantially, reflecting the very different applications of carbon pricing among countries. In particular, some larger economies currently feature low ECRs, and this significantly increases the carbon pricing gap, due to their weight in overall emissions.

Figure 4.15. **Carbon pricing gap, focusing on priced and unpriced emissions below EUR 30**



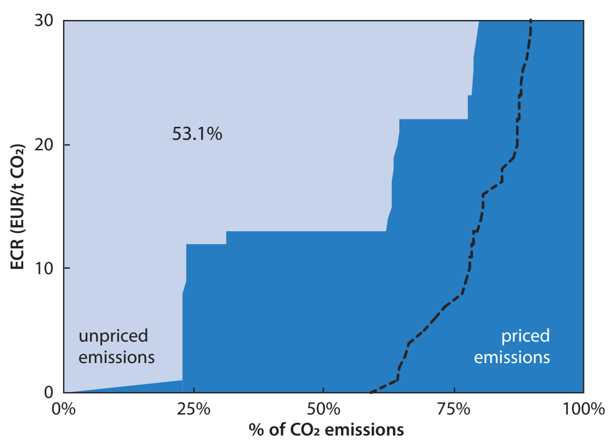
A counterfactual scenario: increase prices and coverage to at least current median levels

The carbon pricing gap presently equals 80.1% as shown above. If carbon pricing is to play a more significant role in climate policy, this gap needs to decline. Reductions can be achieved in at least two ways, first, by extending the share of emissions subject to a price and, second, by increasing the price level of either taxes or trading systems. Both avenues are under consideration in many of the countries considered, and are likely to be increasingly relevant following the Paris Agreement. For example, China is planning to implement a national ETS in 2017 (National Development and Reform Commission, 2016), which will significantly increase the global share of CO_2 emissions from energy use subject to a carbon price. In the European Union ETS, the low prices of tradable emissions permits triggered the development of a market stability reserve. This reserve will start operating as of 2018 (European Commission, 2016) and will remove surplus emissions permits from the market, which is expected to lead to higher carbon price levels. Increases in carbon pricing via taxes are also underway in a few countries. For example, a carbon tax is set to be levied in Chile and in the Canadian province of Alberta starting in 2017, and a draft carbon tax bill has been the subject of consultation with stakeholders in South Africa.

The analysis of ECRs has revealed that they are very often low and that there are large differences between countries, both on an economy-wide basis and also within the six sectors analysed. It follows that improving the performance of countries with low rates or low coverage in any of the sectors would reduce the carbon pricing gap. To make this notion more tangible, a counterfactual scenario was calculated. This scenario is constructed in two steps. First, the median coverage and the median ECR (for emissions covered by an ECR) are identified for each of the six sectors. (The median countries are different in all cases but one and are regionally and economically very diverse.) Second, for each country, the coverage and the ECR are increased to at least the median level. If coverage or ECR level already were higher than the median, they are left as is. In other words, the distribution of coverage and rates is modified by increasing countries at the low end to the median of the currently observed distribution in both coverage and rates. Energy use is kept constant in this exercise, so behavioural effects of the price changes are not accounted for. Since the counterfactual scenario involves price increases, energy use and carbon emissions in fact would decline as a response to higher prices.

The carbon pricing gap in the counterfactual scenario is 53.1%. This says that, if ECR rates and coverage in each of the six sectors would increase to the median levels for those emissions where observed rates and coverage are below the median, 53.1% of emissions would be priced at less than EUR 30 per tonne of CO_2. This is a decline of 27%-point, or of 34%, compared to the current carbon pricing gap of 80.1%. Figure 4.16 shows how the counterfactual scenario affects the distribution of ECRs. ECRs are higher everywhere than in the current situation, but more so near the low end of the distribution. This reflects the fact that country differences are particularly large in sectors with low ECRs, so that reducing heterogeneity by bringing all countries to median price and coverage levels leads to relatively large ECR increases. The median coverage in electricity is 100%, and for industrial emissions it is 59%, and the rates on covered emissions in both cases are around EUR 11 per tonne of CO_2, resulting in the two plateaus seen in Figure 4.16. Median coverage is lower for residential and commercial emissions (at 30%) but the minimum rate is just over EUR 20 per tonne of CO_2.

Figure 4.16. **Carbon pricing gap under counterfactual scenario of median prices and coverage**



To sum up, the counterfactual scenario illustrates that "catching up" with median performance results in strong reductions of the carbon pricing gap. Median performance is not obviously related to country characteristics including GDP, energy use and carbon intensity of energy. While median performance may not be equally easy to attain for every country, it is not necessarily out of reach because of its particularly high level of ambition either.

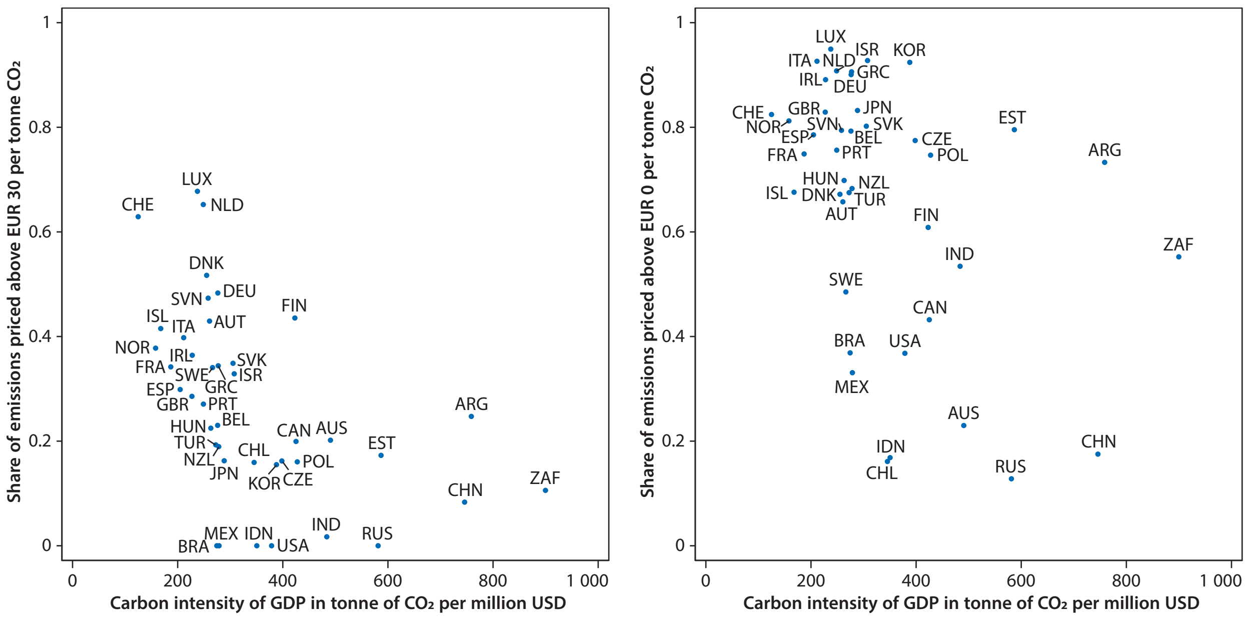
Effective carbon rates and macroeconomic characteristics

ECR levels and the share of emissions that are priced at different rates vary substantially across countries, as the previous sections have shown. To shed some light on factors that potentially help explain these differences, this section relates, for each country, the level and coverage of ECRs to four macroeconomic characteristics of each country: total CO_2 emissions, gross domestic product (GDP), population size and net energy imports.

Figure 4.17 plots the carbon intensity of the economy in each country against ECR coverage in that country. The left panel shows the proportion of emissions facing an ECR at or above EUR 30 per tonne of CO_2, and the right-hand panel depicts the proportion of emissions facing an ECR above EUR 0 per tonne of CO_2.

Figure 4.17 demonstrates that countries that price a high share of CO_2 emissions above EUR 30 per tonne of CO_2 tend to have a low carbon intensity of GDP (left panel). The same holds to a lesser degree for ECRs greater than zero (right panel). The right-hand panel also shows that a cluster of mostly European economies, together with Israel, Japan, and Turkey, display both a relatively high share of priced emissions and have relatively low carbon intensities of GDP, but there is more heterogeneity among countries with relatively high carbon intensities of GDP.

Figure 4.17. **Proportion of CO_2 emissions priced above EUR 30 (left) and EUR 0 (right) per tonne of CO_2 relative to the carbon intensity of GDP, 41 countries, 2012**



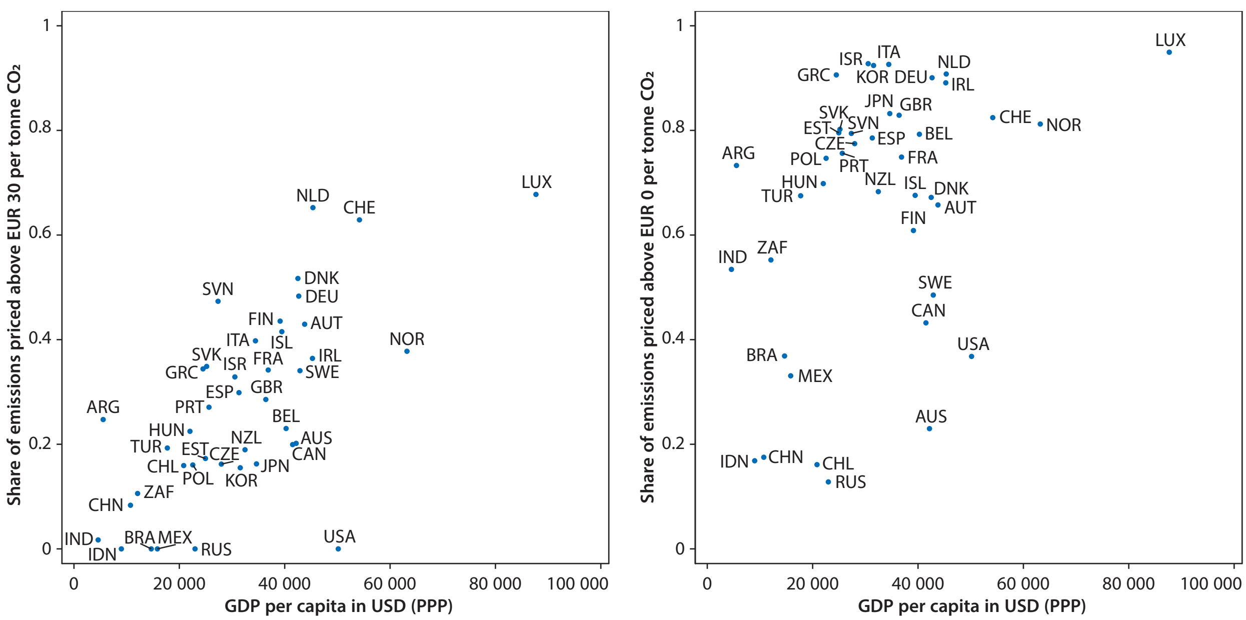
Source: GDP data is from the World Bank (2016), *World Development Indicators* (database), http://data.worldbank.org/data-catalog/world-development-indicators.

The inverse relationship between the proportion of emissions priced at different carbon rates and the carbon intensity of GDP does not necessarily imply a direct causal effect in either direction. A low carbon intensity of GDP may be the result of carbon pricing policies that reduce energy consumption or steer towards less emission-intensive energy sources. However, it may also be the case that countries with low carbon intensities of GDP find it easier to implement stricter carbon pricing policies. That said, there is strong empirical evidence that higher carbon prices discourage emissions, and reducing emission intensities is one way of doing so.

Figure 4.18 displays the same levels of ECR coverage (at EUR 30 and EUR 0, left and right panels respectively) against GDP per capita. It shows that increasing per capita income is associated with higher ECR coverage. Countries with higher per capita incomes tend to price greater shares of emissions above EUR 30 per tonne of CO_2 (left panel). Exemptions to this pattern occur in the United States, which prices a low share of emissions above EUR 30 per tonne of CO_2, despite its relatively high income levels, and Argentina, which prices a relatively high share of emissions above EUR 30 per tonne of CO_2 despite its relatively low income level.

The relationship between the share of emissions with an ECR above EUR 0 per tonne of CO_2 and GDP per capita is less pronounced (right-hand panel of Figure 4.18). Many countries located towards the middle of the income distribution price a significant share of emissions at least at some positive price. At the same time, some high income countries price a comparatively low share of emissions. Both panels of the figures show that, while high income countries are more likely to price a high share of emissions above EUR 30 per tonne of CO_2, many countries with a lower GDP per capita also implement carbon prices, though typically at lower levels.

Figure 4.18. **Proportion of CO_2 emissions priced above EUR 30 (left) and EUR 0 (right) per tonne of CO_2 relative to GDP per capita**



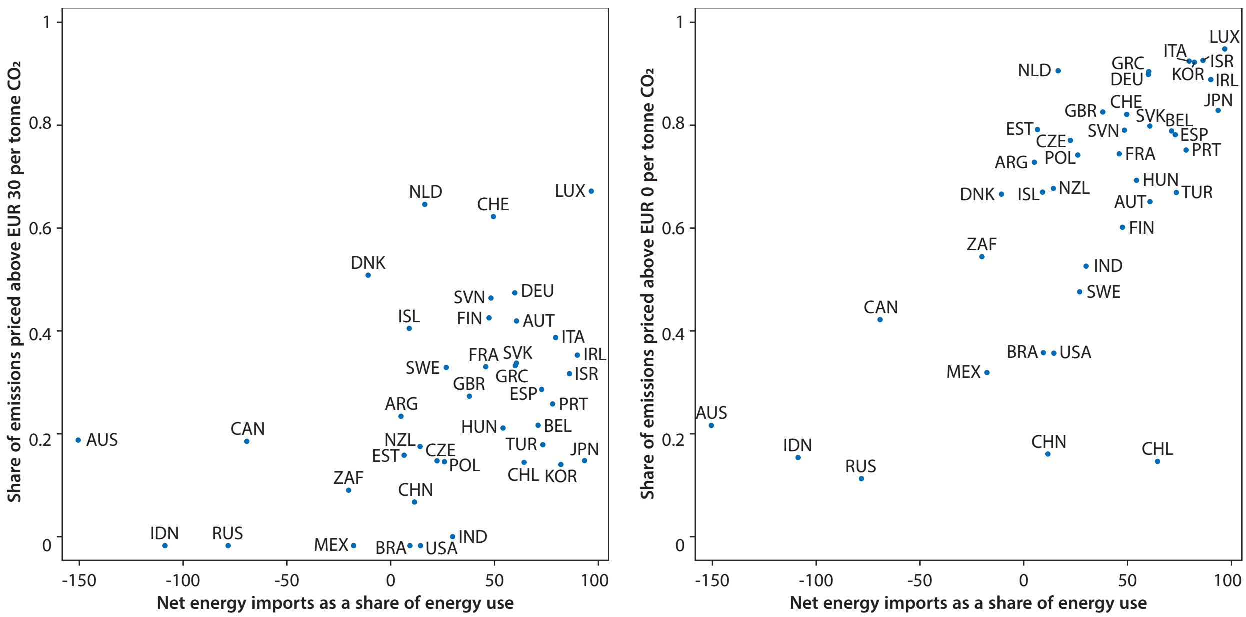
Source: GDP data is from the World Bank (2016), *World Development Indicators* (database), http://data.worldbank.org/data-catalog/world-development-indicators.

Countries' carbon pricing policies may be related to the share of energy imports in a country. Figure 4.19 shows the share of emissions in each country with ECR above EUR 30 per tonne of CO_2 (left-hand panel) and above EUR 0 (right-hand panel) against each country's net energy imports. Net energy imports are defined as a country's total energy use less its production, divided by its energy use. Energy-importing countries have a positive value for net energy imports, with 100% implying that the country imports all of its energy. Energy exporters show negative values for net energy imports. There is no lower limit for negative energy imports as countries can export more than their own energy use. One such country, Norway, is omitted from the graphs due to the very high proportion of energy exports (Norway exports 581% of its energy use, according to World Bank, 2016).

Net importers of energy tend to price a larger share of their emissions above EUR 0, as the right-hand panel of Figure 4.19 shows. This relationship is also observed with the share of emissions priced above EUR 30 per tonne of CO_2 (left-hand panel), although to a lesser extent.

To summarise, higher ECRs tend to be associated with higher and less carbon-intensive levels of GDP, and higher energy imports correlate with higher ECRs.

Figure 4.19. **Proportion of CO_2 emissions priced above EUR 30 (left) and EUR 0 (right) per tonne of CO_2 relative to net energy imports**



Source: Net energy imports are from the World Bank (2016), *World Development Indicators* (database), http://data.worldbank.org/data-catalog/world-development-indicators.

Notes

1. For example, if 50% of non-road emissions in a country face no carbon tax, 25% are subject to a carbon tax of EUR 10, and 25% to a carbon tax of EUR 20, then the average rate of the carbon tax component of the ECR would be EUR 7.5 (0.5 x 0 + 0.25 x 10 + 0.25 x 2 0).

2. The taxes on electricity consumption included in the *Taxing Energy Use* database are shown as indirect taxes on the fuels used to generate electricity, and are aggregated with specific taxes on energy on fuels used for the generation of electricity, where applicable. As explained in more detail in the TEU publications (OECD 2013 and OECD 2015a), the price signal from taxes on electricity consumption does not distinguish between the different fuels used for the generation of electricity, and thus does not encourage reducing the carbon intensity of fuel used to generate electricity.

3. Due to differences in data on emissions trading systems and taxes, there is some uncertainty associated to the proportion of emissions covered by both taxes and ETS in the industrial sector. Total combined ETS and tax coverage as presented in Figure 4.10 represent a point estimate of this overlap, which may be slightly higher or lower in reality. (For example, at a given ETS and tax coverage, the total coverage in the industry sector in the Czech Republic might be 10 percentage points higher or lower than indicated in Figure 4.10.) Annex A provides details on the methodology used to estimate this overlap.

4. In cases where taxes do not apply because a source is subject to an ETS, these taxes are not included in the tax rate shown in the figures.

References

European Commission (2016), "Structural reform of the European Carbon Market", http://ec.europa.eu/clima/policies/ets/reform/index_en.htm (accessed 8 March 2016).

Johansson, Å. et al. (2013), "Long-Term Growth Scenarios", *OECD Economics Department Working Papers*, No. 1000, OECD Publishing, Paris, http://dx.doi.org/10.1787/5k4ddxpr2fmr-en.

National Development and Reform Commission (2016), "National carbon emissions trading market to start", Notice [2016], No. 57, www.ndrc.gov.cn/zcfb/zcfbtz/201601/t20160122_772123.html (accessed 25 February 2016).

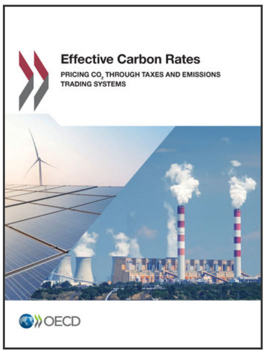
IEA (2016), "Extended world energy balances", *IEA World Energy Statistics and Balances* (database), International Energy Agency, Paris, http://dx.doi.org/10.1787/data-00513-en.

OECD (2016), "6A Value added and its components by activity, ISIC rev4", *OECD Stat*, (database), http://stats.oecd.org (accessed 11 Feb 2016).

OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264232334-en.

OECD (2013), *Taxing Energy Use: A Graphical Analysis*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264183933-en.

World Bank (2016), *World Development Indicators* (database), The World Bank, Washington, DC, http://data.worldbank.org/data-catalog/world-development-indicators.



From:

Effective Carbon Rates

Pricing CO2 through Taxes and Emissions Trading Systems

Access the complete publication at:

https://doi.org/10.1787/9789264260115-en

Please cite this chapter as:

OECD (2016), “Effective carbon rates: Results of the analysis”, in *Effective Carbon Rates: Pricing CO2 through Taxes and Emissions Trading Systems*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264260115-8-en