Levelling global carbon pricing for an inclusive, modern and sustainable energy roadmap

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The Global Carbon Price (GCP): a proposal for COP 26 in Glasgow

The fight against climate change is a global public good. While the Agreement that will be negotiated in Glasgow can only be global, its implementation will have to be local as it will be driven by each individual signatory State.

International institutions are assuming their essential role in promoting the exchange of knowledge and developing tools to spread world energy access (SDG7), foster new sustainable growth, while reducing the levels of production and consumption of energy from fossils fuels. Leaders will have to discuss new goals in Glasgow, urging wealthy industrialized countries to honor commitments, despite the financial constraints of the coronavirus pandemic. They must meet the existing one on climate finance - that is, the yet to be funded $100 billion dollars a year agreed in Copenhagen 2009 - and then go further. Financial assistance is needed for developing countries in the fight against the climate crisis. "Voluntary policies are insufficient," writes William Nordhaus, Nobel laureate in economics in 2018 "agreements must be based on obligations and sanctions." Yet, this vision seems hardly adoptable today. A viable path, matured after the heated debate on the earlier responsibilities of industrialized countries and on the current trend of emissions, is to promote shared tools and win-win solutions.

A Global Carbon Price (GCP) -not to be viewed as a tax- has the qualities of a win-win solution.

A global carbon price can move the climate policy frontier forward.

Three essential elements make it work: **1.** it includes negative environmental externalities that are not yet priced today among the energy costs (as shown in scientific literature, Part One, and also in Parts Two and Three) and, where implemented, carbon price has been found to be effective in reducing CO2 emissions, mainly generating improvements in terms of energy efficiency and recording the lowest carbon intensity of GDP values in countries where carbon pricing is the highest (Part Three); **2.** It curbs environmental dumping, since it affects every country, in particular, the major polluters; it also reduces "carbon leakage" and is fair in terms of rules of international competition since it is applied homogeneously worldwide. **3.** Finally, (FTF) - considering the 36 billion tons of emissions produced a year (2019), even a low carbon price per ton would generate a significant financial contribution. This, in turn, should be calculated to best fit the different levels of development of the regions in which it is applied and recognizing the results of the policies.

Furthermore, the Agreement will have to leave the choice of the tools to be included in the carbon price to the States, consistently with their fiscal and institutional conditions. The GCP will therefore have to include all the available mechanisms (Part One), which are tradable emission permits (the European **ETS** used more and more around the world), the **carbon tax**, also widespread, for example, in the Nordic countries – in Sweden, Denmark, Canada among others -, and **excise duties** – high, for example, in Italy on gasoline. While excise duties may have been destined for other uses, they contribute to increasing the carbon price to reach the global level established.

Flexibility is the key to implementation by governments, as long as every ton of carbon emitted is priced the same in the world. A share of the revenues from carbon pricing would remain at the country level, while a flexible share could be directed to the Fair Transition Fund. This share would

be calculated according to specific countries' characteristics and parameters. The rationale behind the proposal is that the share of carbon pricing revenue to be periodically assigned to the Fund would be proportional to (i) the countries' GDP (addressing the financial gap in developing countries); (ii) countries' progress in carbon intensity of GDP, thus rewarding countries that are making efforts on the path toward decarbonization and (iii) countries' historical contribution to the overall stock of CO_2 in the atmosphere from pre-industrial times.
In addition, **subsidies** for fossil fuels can be gradually reduced and eventually abolished (Part Four), freeing up States resources that can be used, instead, for green and sustainable investments or to compensate citizens for the costs of mitigation and adaptation.

The Fair Transition Fund from GCP. In a nutshell, the distribution and uses of the fund are essential to creating a new global cooperative spirit and contributing to a decisive green transition in countries at different levels of development - reforestation, adaptation, clean cooking and climate risks coverage may be among the most direct measures. Above all, the FTF will have to target the unfair consequences of climate change and support developing countries in activating policies of prevention, resilience and adaptation to climate change. The distribution of the *Fund* to developing countries would depend on their relative population and their socio-economic level, measured in term of Human Development Index, on their status regarding the three outcome target envisaged by SDG 7: the access to affordable, reliable and modern energy services, the share of renewable energy in the energy mix and the improvement in energy efficiency. The final component to compute the distribution of the Fund depends on countries' vulnerability to climate change impacts and their readiness to face them.

The flexibility of the instruments included in the carbon price – ETS, carbon tax, excise – enables the countries contributing to its formation a free and appropriate choice of fiscal policy, while also making it acceptable to large emitters. Finally, a global homogeneous price of carbon would avert competitive distortions in international trade. It can be monitored by already existing supranational institutions

The specific aspects of the GCP are detailed in the following 5 parts of the paper, offering an analysis of the potential effectiveness of the GCP, based on an empirical comparison of data elaborated from different official sources.

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PART ONE – Carbon pricing in the literature

- Carbon pricing reveals the hidden cost of greenhouse gas pollution and affects emissions by penalizing emission sources according to their carbon content. The carbon pricing methods can be traced back to three main forms: cap-and-trade systems, carbon tax and sanctions (plus, some implicit forms of carbon pricing, such as excise duties on fossil fuels).
- The carbon pricing level is tied to variables of various orders: environmental, social, political, technological and economic.
- In addition to complying with the "*polluter pays* principle", carbon pricing positively influences the behaviour of businesses and consumers in the direction of reducing CO_2 emissions. At the same time, it stimulates innovation and the creation of green products, processes and clean technologies.
- Compared to other solutions, carbon pricing shows greater effectiveness and flexibility in its application to heterogeneous emission sources, and lower information and transaction costs. Furthermore, it makes the integration of different mechanisms possible and, if applied globally, reduces carbon leakage and dumping without the need for sanctions.

1.1 Why carbon pricing. Contributions from economic theory and empirical research

As defined by the World Bank, "*Carbon pricing is an instrument that captures the external costs of greenhouse gas (GHG) emissions—the costs of emissions that the public pays for, such as damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise—and ties them to their sources through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted*"[2]. Carbon pricing, therefore, creates a financial incentive for companies, consumers and countries to reduce their emissions, moving to more efficient and cleaner processes, products and technologies. In this way, it harnesses market forces to combat climate change. Climate change, in fact, is regarded by economic theory as a market failure. It entails, for current and future generations who will suffer its consequences, significant costs and risks, which are not normally reflected in current market prices. Carbon pricing reveals the hidden cost of greenhouse gas pollution and affects emissions by penalizing emission sources on the basis of their carbon content.

The carbon pricing methods can be traced back to three main forms: cap-and-trade systems, carbon tax and sanctions.

Cap-and-trade systems

Cap-and-trade systems are the major type of Emission trading Systems. They deal with three main issues: the definition of the quantities of emissions, the level of permits and the volatility of prices. In fact, cap-and-trade mechanisms require the government to set a limit on the total amount of

[2] World Bank, What is carbon pricing? : https://carbonpricingdashboard.worldbank.org/what-carbon-pricing

emissions allowed. CO_2 emitters then either receive permits for free or have to purchase the right to emit CO_2. Companies whose total emissions are below their cap can choose to sell unused carbon credits to those who exceed their carbon allocation. Emissions trading systems (ETS) aim for cost-effective emissions abatement and staying below certain emissions levels (Driessen, 2018; World Bank, 2021). Cost-effectiveness is reached because, under an ETS, the industries that need to comply with emission targets can either implement internal abatement measures or acquire emission allowances (or credits), depending on the relative costs of these options (World Bank, 2021). In other words, in ETS, polluters can trade their emission control obligations to realize cost-effective abatement (Driessen, 2018). One crucial feature of emission trading systems is the cap definition. An insufficiently stringent cap, i.e., an excessive supply of emission allowances, results in low demand and low prices. This issue was observed in the EU ETS (Driessen, 2018; Zaman, 2016). Starting an emissions trading system with smaller numbers in terms of allowances, participants, or gases covered, and gradually broadening its scope can limit problems of oversupply of allowances (Zaman, 2016).

A potentially high volatility of allowance prices is a challenge for emissions trading systems. A stable price signal definitively incentivizes firms to change their investment decisions to favour emissions reduction. With the aim of reducing price volatility, different policy instruments have been proposed to work together with emissions trading systems, such as price ceilings, price floors (as can be found in the UK and Canada) and an allowance reserve. An example of the EU ETS, a market stability reserve (MSR) was added to the system in its fourth phase to maintain a reasonably stable level of allowance prices. Despite the use of these instruments, a certain level of volatility will remain, as will the need to understand and predict prices (Zhang, 2020).

Carbon tax

Under the carbon tax approach, the government charges CO_2 emitters for each tonne released through a tax or fee. Based on their carbon content, the government can impose a carbon tax on the distribution, sale or use of fossil fuels. In this way, a carbon tax guarantees the carbon price in the economic system against uncertain outcomes. According to a statement made by US economists on Carbon Dividends[3], "the largest public statement of economists in history", a carbon tax offers the most affordable leverage to reduce carbon emissions to the scale and speed needed. It should increase every year until emission reduction targets are met and be revenue-neutral in order to avoid debates over the size of government. Furthermore, a sufficiently robust and gradually increasing carbon tax will replace the need for various, less efficient carbon regulations. Carbon tax has distributive impacts. In the opinion of the economists signatories of the statement, all revenue should be returned directly to citizens through equal flat rate rebates, to maximize fairness and the political viability of a rising carbon tax. Ultimately, most households, including the most vulnerable, will receive more "carbon dividends" than they pay with rising energy prices. Therefore, they will benefit financially from carbon tax.

[3] https://clcouncil.org/economists-statement/

The Stanford Energy Modelling Forum recently completed a study on the economic results of introducing a carbon tax in the United States. It turns out that a carbon tax is effective in reducing carbon pollution, although the structure of the tax - namely the price and the rate at which it increases - is important. A tax implemented in 2020 at USD 25 per t CO_2 emitted from fossil fuels would reduce annual emissions by approximately 6-18% in the short term, mainly due to the substitution of coal for natural gas to produce electricity. The study also notes that the rate of increase of the carbon tax is more important than the starting price. For example, a tax of USD 50 per t CO_2 that increases by 5% per year would reduce carbon pollution by 33-56% in 2040. A tax of $25/t$CO_2$ that increases by 5% per year would cut carbon pollution by 25-50% over the same period. Conversely, policies that include a tax increase of just 1% per year would only result in a short-term reduction. Carbon pollution would then remain stable at those levels. These results suggest that the most effective carbon tax could start relatively low to allow taxpayers to adjust, but should increase rapidly over time.

Driessen (2018) emphasizes that governments usually use a pollution tax or an emissions trading program in conjunction with other programs. However, the interaction of these instruments with other mechanisms produces different results regarding additional emission reductions. In the presence of emissions trading, an additional program aiming to reduce emissions will often not add emission reductions. Since the emitter has the legal right to sell emission allowances, if emissions are reduced through the additional program and the respective allowances are sold, there is no net emissions decrease. "A new program will only reliably generate additional progress if those realizing the reductions generated under that new program cannot sell credits" (Driessen, 2018: 57).
Differently, in the context of a pollution tax, a supplemental environmental program addressing pollution usually results in net pollution reductions. From the polluter's point of view, pollution taxes may even encourage the adoption of additional programs since the reduction in emissions will decrease the amount of tax paid (Driessen, 2018).

Sanctions and excises

Carbon pricing concerns measures that impose an explicit price on GHG emissions, for example a price expressed as a value per tonne of carbon dioxide equivalent. The sanctions are instead applied to companies and countries that do not adopt climate policies or have too low emissions or environmental standards. As carbon pricing entails an explicit price on GHG emissions, for example, a price expressed as a value per tonne of a carbon dioxide equivalent, other measures, notably excises and subsidies, can be considered “implicit carbon pricing” (World Bank, 2019). In Part Two and Three of this report, data on this type of implicit pricing will be discussed. The very low excise duties and taxes on gasoline and diesel in the United States - about one fifth of the total price - are believed to play an important role in per capita emissions, which are about two to three times those observed in Europe, where taxes account for about 60% of the consumer's fuel price (Burggraeve et al., 2020).

The fact that excise duties are an implicit form of carbon pricing also emerges from some national experiences. Around 2000, Sweden strengthened its carbon taxation mechanism. At the same time, it re-labelled some of its existing fuel taxes as a carbon tax, which neutralized the effect of the carbon tax increase on the total fuel price. The future path of the carbon tax was also clearly announced at that time. The French government acted similarly by fully offsetting the introduction of the carbon tax in 2014 with a cut equivalent to an existing indirect tax, allowing for a smooth transition. Again, the fiscal path was clearly communicated (Burggraeve et al., 2020). An important distinguishing feature of a carbon tax compared to a normal excise tax is clearly tracing and communicating the tax's growth path toward.

On the contrary, subsidies reduce the price of carbon or more specifically reduce the final-user cost of products containing carbon. For these reasons, subsidies for fossil fuel production or use, which lead to emissions of carbon dioxide or tax exemptions, can be considered forms of implicit negative carbon pricing.

Carbon pricing

The idea of global carbon pricing has long been a recurrent topic in the climate policy debate at various levels. In recent years, carbon prices have increasingly been adopted to combat the risks of climate change. By the end of 2020, however, they covered about 16% of global emissions (World Bank, 2020). Furthermore, current carbon price levels are generally too low to substantially reduce the risks of climate change (United Nations, 2018). The price of carbon is related to numerous variables of different orders: environmental, social, political, technological and economic. For example:

- Cross-national studies show that countries with greater public distrust in politicians and higher perceived corruption persistently show weaker climate policies and higher greenhouse gas emissions. Specifically, there is a negative correlation between public distrust or perceived corruption and carbon price levels (Baranzini et al. 2014, Rafaty 2018, Klenert et al.,2018);
- On the contrary, as income grows, the willingness to pay for environmental protection also seems to increase. Skovgaard et al. (2019) have shown an effect of income on the early adoption of the carbon price;
- Similarly, education contributes positively to awareness of climate risks (Lee et al., 2015);
- Conversely, there are significant negative effects of per capita coal reserves on carbon price and carbon tax intensity (Best and Zhang, 2020). This is because coal is the most carbon-intensive fossil fuel and larger reserves can contribute to carbon price resistance where there are strong vested interests;
- Furthermore, the size of internal credit stocks, rather than the flow of annual income, is correlated with higher carbon pricing (Best and Zhang, 2020). In fact, stocks seem to be of greater importance for long-term changes in energy systems (Best, 2017). Greater economic resources can provide countries with a greater capacity to undertake a more challenging climate policy that addresses capital-intensive energy sectors.

There are numerous empirical studies that testify to the effectiveness of carbon pricing, both conducted from an international perspective and on individual countries and specific sectors. Best et al. (2020), for example, using data over a two-decade period for 142 countries - 43 of which having implemented carbon prices at the national or lower level at the end of the study period - found that the average annual growth rate of CO_2 emissions from fuel combustion was about 2 percentage points lower in countries with a carbon price than in countries without. All other things being equal, an extra euro per tonne of CO_2 in the carbon price is associated with a reduction in the subsequent annual growth rate of emissions by approximately 0.3 percentage points. Andersson (2019), analyzing the implementation of a carbon tax and a value added tax on transport fuel in Sweden, found that carbon dioxide emissions from transport fell by nearly 11%, with the higher share due to the carbon tax alone, compared to a synthetic control unit built by a comparable group of OECD countries[4].

A world carbon price was discarded by the 2009 Copenhagen Conference of the Parties, but it still formed part of the deliberations for a climate deal in subsequent years. There remains, however, resistance to the implementation of such a measure, and among those in favor, a diversity of views on the best instruments to adopt (essentially, whether a carbon tax or emissions trading systems) and on which emissions to apply pricing (for example, whether only to emissions deriving from energy uses or to a generality of polluting sources).

There is certainly no lack of reasons for using carbon pricing, both in terms of economic efficiency and environmental effectiveness (Baranzini et al., 2016). By contrast, actions to reduce polluting emissions represent global public goods and involve costs that are as high as the established CO_2 abatement threshold. For these reasons, free riding behaviours on the part of some states may allow them to reap benefits without compromising the competitiveness of national companies. It is therefore necessary to coordinate actions in the international forum to prevent leakage and dumping of carbon emissions at a global level and to guarantee a fair competition among countries.

Polluter Pays **Principle**

As stated by the European Association of Environmental and Resource Economists (EAERE) "*A price on carbon offers the most cost-effective lever to reduce carbon emissions at the scale and speed that is necessary. By correcting a well-known market failure, a carbon price sends a powerful signal, steering economic actors towards a low-carbon future. This encourages technological innovation, large-scale infrastructure development, as well as the diffusion of carbon-efficient goods and services*". The main reason for resorting to carbon pricing identified by economic theory is the need to internalize the environmental costs of emissions, in compliance with the "polluter pays" principle (Polluter Pays Principle). Carbon taxation, in fact, changes relative prices. Therefore, companies and consumers, when making decisions that cause carbon emissions, will be forced to go beyond their

[4] Furthermore, the carbon tax elasticity of gasoline demand is estimated to be three times greater than the price elasticity. Policy assessments of carbon taxes that use price elasticity to simulate emission reductions can significantly underestimate their true effect.

own benefits and costs, and consider the direct and indirect social costs of carbon emissions generated over the cycle of the product, from raw material to waste. If the carbon price were high enough to steer businesses and consumers toward making the necessary adjustments, energy systems and the economy could considerably reduce the carbon intensity of the economy[5].

Carbon pricing and innovation policies

Carbon pricing integrates well with technological innovation policies (Acemoglu et al., 2012). By increasing the costs of more carbon-intensive activities, companies are incentivized to invest in research and development of green processes and products. There is a positive relationship in the literature between higher energy prices and the adoption of clean technologies (Ambec et al., 2012). For example, in Australia, during the enforcement period of a carbon pricing scheme (from July 2012 to July 2014), companies accelerated the adoption of cleaner technologies (Bakhtiari, 2018). Much of this growth is due to companies lagging in technology and failing to catch up with the frontier. While front running facilities have constantly improved their technologies and the carbon price has only pushed them to move faster, less innovative facilities tend to lag behind in the absence of carbon prices and are later compelled to catch up with the front running facilities only upon application of the carbon price. The reallocation of activities, mostly within electricity, gas & utilities sector companies, towards cleaner and more efficiently scaled facilities have led toward a reduction of emissions. All of these activities cease when the carbon price is abolished. These patterns are strongly linked to the introduction or abrogation of carbon pricing; there is a clear correlation between the carbon price and observed changes. Aghion et al. (2012), through company-wide data on automotive industry innovation, distinguishing between "dirty" (internal combustion engine) and "clean" (e.g., electric and hybrid) patents in 80 countries over several decades, show that companies tend to innovate relatively more in clean technologies when faced with higher tax-inclusive fuel prices. Boqiang and Wesseh (2020), analyzing China's national emissions trading scheme, found a significant and positive effect on R&D investment, especially R&D intensity. Without prices that internalize the costs of pollution, technological innovation would not be oriented in the socially desirable direction.

Carbon pricing and consumers

The incentive also works on the demand side, as consumers would increase the demand for sustainable solutions. It emerges from sector studies that the generality of consumers, despite growing environmental awareness, is not very attentive to choices with an environmental impact in their purchasing. This is also because the single action has negligible effects on larger phenomena. Without assuming that economic agents act in a virtuous or altruistic way, by intervening on the price, one imagines to direct individual choices more effectively. On the other hand, social learning

[5] In 2018, compared to a world average of 2.4 t CO2 / toe, the CO2 intensity of the energy mix was 3 for China, 2.2 for the United States and 2 for the European Union. 28 (source: IEA).

theories are highlighting the importance of imitative factors for the diffusion of sustainable behaviours among people and also among companies (van der Linden, Maibach and Leiserowitz, 2015, Saleem et al., 2021). Generally, the participation of citizens and a higher sense of civic duty (as found in the countries of Northern Europe) positively influence environmental sensitivity and behavior.

Carbon pricing flexibility

Furthermore, if compared to other instruments, carbon pricing shows an appropriate flexibility to deal with such a complex phenomenon as CO_2 emissions. In fact, it lends itself to addressing the wide heterogeneity of sources of greenhouse gas emissions and, in this way, is functional to minimizing the costs of containing pollution. The heterogeneity is due, for example, to industries' different sizes, types of organization, and production technologies – a variability that is reflected in several marginal costs of reducing emissions. According to orthodox economic theory, assuming a context of perfect information and rationality of economic agents, emitters should identify the level of emissions reduction at the point where the marginal cost of a tonne of carbon equals its price. By imagining a system that imposes a single carbon price, it follows that the costs of CO_2 abatement would be identical for all polluters. On this basis, a given CO_2 reduction target would be obtained by minimizing global costs.

Carbon pricing efficiency

Although these optimal conditions are impossible to obtain (due to lack of information and rationality of individuals and operators, as well as gaps in the knowledge of production and abatement technologies and the related associated costs), the literature on this topic shows that mechanisms other than carbon pricing are less effective, that is, they have higher emission abatement costs. For example, if carbon pricing constitutes a system that can be easily applied to new types of emissions, other carbon-reducing solutions, such as technical production and emissions standards, cannot be universally applied to the myriad of technologies available or may be too costly to adopt. For example, eco-labelling systems require life-cycle analysis to account for the actual carbon content of products and services. In this way, carbon pricing appears to reduce information and transaction costs. For Pizer (2002) uncertainty about compliance costs causes otherwise equivalent price and quantity controls to work differently and leads to divergent welfare consequences. He concludes that price controls are more efficient. The expected welfare gain from an effective pricing policy is estimated to be five times higher than the expected gain from the most effective quantity policy. At the same time, for Pizer (2002), a hybrid policy is an attractive alternative to either a pure price or quantity system. Fischer and Newell (2008) compare various policies to reduce carbon dioxide emissions and support the spread of renewable energy and innovation, specifically emissions price, emissions performance standard, fossil power tax, renewables share requirement, renewables subsidy and R&D subsidy. They highlight that for anything beyond very small emission reduction targets, the price of emissions is the single most efficient policy for reducing emissions, as it simultaneously offers incentives for fossil energy producers to reduce emissions intensity, consumers to conserve, producers of renewable energy to expand production and invest in knowledge to reduce costs. In their view, the most effective policy portfolio includes an emissions price and subsidies for research and technological development and learning.

Carbon leakage and dumping prevention

In addition, as previously mentioned, a carbon pricing system applied internationally would prevent carbon leakage and dumping. If some States, however, fail to introduce pricing, trade sanctions could be applied to free riding polluters, as suggested in current literature (Nordhaus, 2015). Sanctions could also take the form of carbon tax at the border, to be applied to imports from non-compliant countries or with inadequate emission standards (an example is the Carbon Adjustment Border Mechanism being studied by the European Commission). Nevertheless, a measure of this kind does not automatically guarantee the global implementation of an adequate climate policy. In fact, alternative policies based on technology transfer from developed to developing economies might be more effective as a solution to carbon leakage and do not raise concerns about equity in distribution of mitigation responsibilities (Cappelli et al., 2021).

Furthermore, carbon pricing could be more effective than other methods in dealing with the Jevons paradox and, in general, with the rebound effects (van den Bergh, 2011). The savings achieved through advances in energy efficiency would be directed less towards cheaper products and technologies with a high carbon content.

Carbon pricing revenues

The revenue from carbon pricing could be used by States in various ways, from promoting sustainable development to reducing labor taxes; investing in research and development to combatting the social and distributive impacts of carbon pricing (see Part Four of this report). The allocation of the proceeds of carbon pricing and issues of equity and distributive effects are a major concern for citizens with regard to carbon pricing (Maestre-Andrés et al., 2019). To cope with the distributive impact of a higher price of fossil fuels, the concept of equal per capita dividends is also gaining ground (Boyce, 2018). According to various estimates, the carbon price could raise funding to meet the investment needs for basic infrastructure. In this way, carbon pricing revenues could fill infrastructure access gaps, helping to cover infrastructure investment needs in most countries (Jakob, Chen, Fuss et al., 2016).

PART TWO – Carbon price: assessments of required price levels and those currently observed

Paragraph 2.1 illustrates carbon price level estimates that would be required to be in line with the Paris Agreement goals. Paragraph 2.2 shows current levels of different carbon pricing instruments that could inform the implementation of a minimum global carbon price.

Main findings are the following:

- The IPCC, the High-Level Commission on Carbon Prices and the IEA have proposed carbon price levels compatible with the objectives of the Paris Agreement. These levels range from $ 40-80 in 2020 to $ 50-6,050 /tCO_2 in 2030, depending on the policy context.
- However, prices observable today vary considerably, and most prices remain far from the proposed ranges. Even countries that sustain relatively high carbon prices do not price all of their emissions. Moreover, it is estimated that approximately 60% of CO2 emissions are not priced, considering 44 OECD and G20 countries responsible for 80% of global emissions.

2.1 Carbon price: the level required

The Carbon price is a price per tonne of CO_2 and CO_2 equivalent (CO_2e) that can be applied to Greenhouse Gas (GHG) emissions.

Estimates of the carbon price level required to be in line with the Paris Agreement vary significantly across models and scenarios. The price level increases with mitigation efforts and decreases with the support of other policies, such as regulatory measures (IPCC, 2018).

Table 2.1 summarizes carbon price findings from three international reports.

Table 2.1: Carbon price in different global warming scenarios, years and policy contexts ($ per tCO_2)

Reference	Global warming scenario	Policy context	Carbon price over the years ($/t$CO_2$)			
			2020	2030	2040	2050
High-Level Commission on Carbon Prices (Stern & Stiglitz, 2017)	2°C	With other policy measures “The pricing policy is complemented with targeted actions and a supportive investment climate – in the absence of these elements, the carbon price range required is likely to be higher” (p. 50)	40-80	50-100	n.a.	n.a.
IPCC (2018)	1.5°C	Without other policy measures	n.a.	135-6050	n.a.	245-14300
IPCC (2018)	Higher-2°C	Without other policy measures	n.a.	15-220	n.a.	45-1050

IEA (2017)	2°C	With other policy measures (“standards and regulations are used as well – as energy efficiency standards -, coupled with support for technology development and deployment to make emerging low-carbon technologies competitive”).	n.a.	75-100	125 - 140	n.a.

Source: Stern & Stiglitz (2017); IPCC (2018); IEA (2017).

Table 2.1 shows that lower carbon price ranges imply that other measures and policies are applied.

Carbon price estimates higher than \$ 80–100 / tCO_2 in the period 2020–30 usually make more pessimistic assumptions regarding the pace of technological advancement and the impact of socioeconomic trends. Higher price ranges also assume an unsupportive policy environment and less support from other policies (Stern & Stiglitz, 2017).

The OECD (2018b) observes that estimates of \$ 40-80 / tCO_2 by 2020 and of \$ 50-100 / tCO_2 by 2030 are low because they assume that carbon prices are introduced in a context where policies are well aligned with climate objectives.

According to the IEA (2017) carbon pricing should be in the range of \$ 75-100 / tCO_2 by 2030, depending on the country. This scenario assumes the use of standards and regulations coupled with support for technology development and deployment to make emerging low-carbon technologies competitive.

2.2. Carbon prices currently observed

Approximately 60% of CO_2 emissions are not priced, considering 44 OECD and G20 countries responsible for 80% of global emissions (OECD, 2021e).

Share of global emissions covered by ETS and carbon taxes and their price level

The IMF (2019) has calculated the global average price of carbon to be only about \$ 2/tCO_2[6].

In 2020, approximately 16% of global GHG emissions were covered by carbon taxes or emission trading systems already in place[7]: 10.7% were under an emission trading system and 5.6% were

[6] The IMF report does not provide details as to how this average value was calculated. The report explains that its discussion on carbon pricing was based on the World Bank report “State and Trends of Carbon Pricing 2018” (IMF, 2019). The World Bank report itself does not compute an average global carbon price. It provides the carbon price of single carbon pricing initiatives and the price range for a given portion (per cent) of emissions (World Bank; Ecofys, 2018). We did not find other computations for a global average price of carbon among our references.

[7] The World Bank analyzed country-level carbon pricing initiatives in 29 countries. Sub-national initiatives in Canada, China and the US were also active, beyond the EU ETS, which is supranational.

covered by carbon taxes. The Chinese ETS to be implemented in 2021 may add 6% of emission coverage (World Bank, 2021).

Globally, in 2020, carbon prices from the ETS and carbon taxes ranged from less than US$ 1/t CO_2e to US$ 119/tCO_2e, with almost half of the covered emissions priced at less than US$ 10/tCO_2e. Among the emissions under a carbon tax or an ETS, less than 5% are in line with the estimated $ 40-80/tCO_2 2020 price range (World Bank, 2020).

Up until 2020, only six European countries[8] had a carbon pricing instrument with prices within or above the $ 40-80/tCO_2 range – notably, a carbon tax. However, there is still a high share of emissions in these countries that are not covered by a pricing instrument (World Bank, 2020). In 2021, the price of EU ETS allowances has surpassed $40/t$CO_2$ (ICAP, 2021b).

Among the largest emitters, the US, India and Russia, did not have a national carbon tax or ETS instrument by 2020. China is starting its national ETS in 2021. Sub-national ETS have been implemented in China and in the US, but their prices are below the $40-80 / t$CO_2$ range. The same is true for Japan (World Bank, 2021).

Average ETS allowance price

From January 2020 until March 2021, the average allowance price among emission trading systems[9] worldwide ranged from $ 1.1 / tCO_2 to $ 45.21 / tCO_2. Although, in the first semester of 2020, most systems experienced a sharp decrease in allowance prices due to the COVID-19 pandemic, the majority of prices recovered by the second half of 2020 (ICAP, 2021a).

The level of emission trading systems varies among supranational (the EU ETS), country and subnational levels (provinces, states and cities). Keeping in mind that several systems correspond to subnational jurisdictions, in table 2.2, the countries of the ETS jurisdiction were considered.

Table 2.2 separates ETS in two groups, according to whether their jurisdictions were in countries included in Annex 1 of the UNFCCC. Among the countries not included in Annex 1 only Kazakhstan is not a G20 member.

[8] Norway (upper price rate: $53), France ($49), Finland (transport fuels price rate: $68; other fossil fuels price rate: $58), Switzerland ($99), Liechtenstein ($99), Sweden ($119).

[9] The source (ICAP, 2021a) considered emissions trading systems (ETS) that are mandatory cap-and-trade systems for GHGs. Other types of ETS, systems concerning other gases and voluntary programs are not considered.

Table 2.2: Average ETS allowance price of trading systems active in 2020.

a) Cap-and-trade systems in jurisdictions that are part of Annex 1 countries

Initiative	Average* allowance price in 2020 ($/tCO₂)
European Union**	28.28
Switzerland	28.45
New Zealand	19.99
Nova Scotia	18.16
California	17.40
Québec	16.97
RGGI (Regional Greenhouse Gas Initiative – includes 11 US States)	7.06
Massachusetts	7.00
Tokyo	5.06

b) Cap-and-trade systems in other jurisdictions

Initiative	Average allowance price in 2020 ($/tCO₂)
Korea	27.62
Beijing	12.62
Shanghai	5.81
Guangdong	4.09
Hubei	3.94
Chongqing	3.82
Shenzhen	3.46
Tianjin	3.28
Fujian	2.50
Kazakhstan	1.10

Notes: Prices are not directly comparable across systems, given differences in ETS design.

Other than these initiatives, the Saitama ETS and the Mexico pilot ETS were also active in 2020. However, no 2020 average allowance price was available for them.

* Average allowance prices in 2020 provided in USD by ICAP (2021a).

** In 2021 the EU ETS entered its 4th phase, which significantly altered the allowance price level. From January to March 2021, the average allowance price of the EU ETS was $45.21/tCO2 (The 2021 average price was provided in EUR by ICAP (2021b) and converted by the authors in USD using an average exchange rate of 1.2048 for the period from January to March 2021).

Source: Authors' own elaboration on data by ICAP (2021a, 2021b).

In 2021, a country level ETS will be implemented in Germany, with a fixed allowance price of $ 28.55/tCO_2$. A national Chinese ETS will also be effective in 2021, but allowance prices are not yet available.

Carbon pricing score

The *carbon pricing score* (CPS) of countries is a measure developed by the OECD to evaluate the extent to which countries have reached the goal of pricing *all* energy related carbon emissions at certain benchmark values for carbon costs. The benchmark values are 30, 60 and 120 EUR[10] (OECD, 2021b).

In 2018, 44 OECD and G20 countries, responsible for 80% of energy-related CO_2 emissions globally, reached together a Carbon Pricing Score of 19% at the 60 EUR benchmark (CPS_{60}). This means that these countries reached only 19% of the carbon pricing goal of 60 EUR for *all* energy related carbon

[10] For example, "a CPS of 100% against a EUR $30/tCO_2$ benchmark means that the country prices all carbon emissions in its territory from energy use at EUR 30 or more. A CPS of 0% means that the country does not impose a carbon price on emissions at all. An intermediate CPS between 0% and 100% means that some but not all emissions are priced at or above the benchmark price". EUR 30/ tCO_2 is an historic low-end price benchmark of carbon costs; EUR 60/ tCO_2 is a low-end estimate of carbon costs in 2030 and a mid-range benchmark of carbon costs in 2020. The EUR 120 benchmark price is a "central estimate of the carbon costs in 2030" (OECD, 2021b: 19).

emissions. The OECD considered carbon taxes, ETS permits prices, and specific taxes on fossil fuels to compute global carbon rates (OECD, 2021b).

Considering the largest emitters, the US reached a CPS_{60} (CPS considering a EUR 60 benchmark) of 22%; China's CPS_{60} was even lower (9%); but the introduction of a national emission trading system (ETS) in 2021 is expected to increase the share of emissions priced. Japan's CPS_{60} was 24%; Russia's 7%, while India recorded a 13% CPS.

In the 23 EU countries studied in the OECD report, emission permit "prices have increased since 2018 and trade above EUR 30/tCO_2 since early January 2021" (OECD, 2021b: 26). At permit prices in the EU ETS of EUR 30, the CPS_{60} increases from 44% in 2018 to 52%. According to the OECD, in order to close the carbon pricing gap entirely "carbon prices would also need to increase in sectors that are currently not covered by the EU ETS and that have low effective carbon rates" (OECD, 2021b: 26), as in the residential and commercial sectors.

If these sectors were included, together with industry, the CPS_{60} would increase to 61%; moreover, if permit prices were raised to at least EUR 60/tCO_2, the CPS_{60} would reach 84% and the remaining pricing gap would be due mainly to biofuels (OECD, 2021b).

Carbon taxes and fuel excise taxes in different groups of countries

Starting from carbon tax and fuel excise tax[11] data provided for 60 countries[12] (OECD 2019; 2021c), we calculated[13] the average carbon price (\$/tCO_2) applied on energy use in each country, to see how close their carbon prices are to the various benchmarks described in table 2.1.

While the World Bank (2020) describes higher carbon taxes for some countries than those provided by the OECD (2019), for the purpose of our study, it was important to use OECD's carbon tax and

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[11] We chose to show only carbon tax and fuel excise tax, excluding ETS, for a few reasons: first, significant ETS are active at a supra-national or sub-national level, thus making it difficult to make cross-country comparisons; second, data on ETS are less extended, detailed and systematized than taxes data, hindering the comparison between sectors and emissions covered by carbon taxes, fuel excise taxes and ETS.

[12] OECD data for 45 OECD and G20 countries are provided in *Taxing Energy Use 2019*, while OECD data for 15 countries not belonging to the OECD or to the G20 are provided by the OECD Stats database available at: https://stats.oecd.org/Index.aspx?DataSetCode=TEUSDCBR, a dataset that is part of the report Taxing Energy Use for Sustainable Development (OECD, 2021d)

[13] Fuel excise and explicit carbon taxes are converted by OECD (2019, 2021c) into effective carbon tax rates per tonne of CO_2 based on the carbon content of the fuels.

As regards the 45 OECD and G20 countries studied in *Taxing Energy Use 2019,* we used the data provided in "Annex 3.A Carbon Tax Profiles". In order to find the average carbon tax and the average excise tax, we started by calculating the revenue from carbon tax and fuel excise tax in each country, multiplying the various tax rates for each sector by the emissions caused by the relative sector; then, we divided the carbon tax revenue by the total emissions, and we did the same for the excise tax revenue. In this way, we found the average carbon tax and fuel excise tax of each country. The graphs show the average carbon pricing as the sum of the average carbon tax and average excise tax. Data in EUR were converted in US\$ with the average 2018 exchange rate provided by the European Central Bank: 1.181.

Regarding the 15 countries outside of the OECD and G20, average fuel excise taxes were already provided in the OECD stats database; these countries do not have a carbon tax, so the carbon pricing reflects the fuel excise tax only.

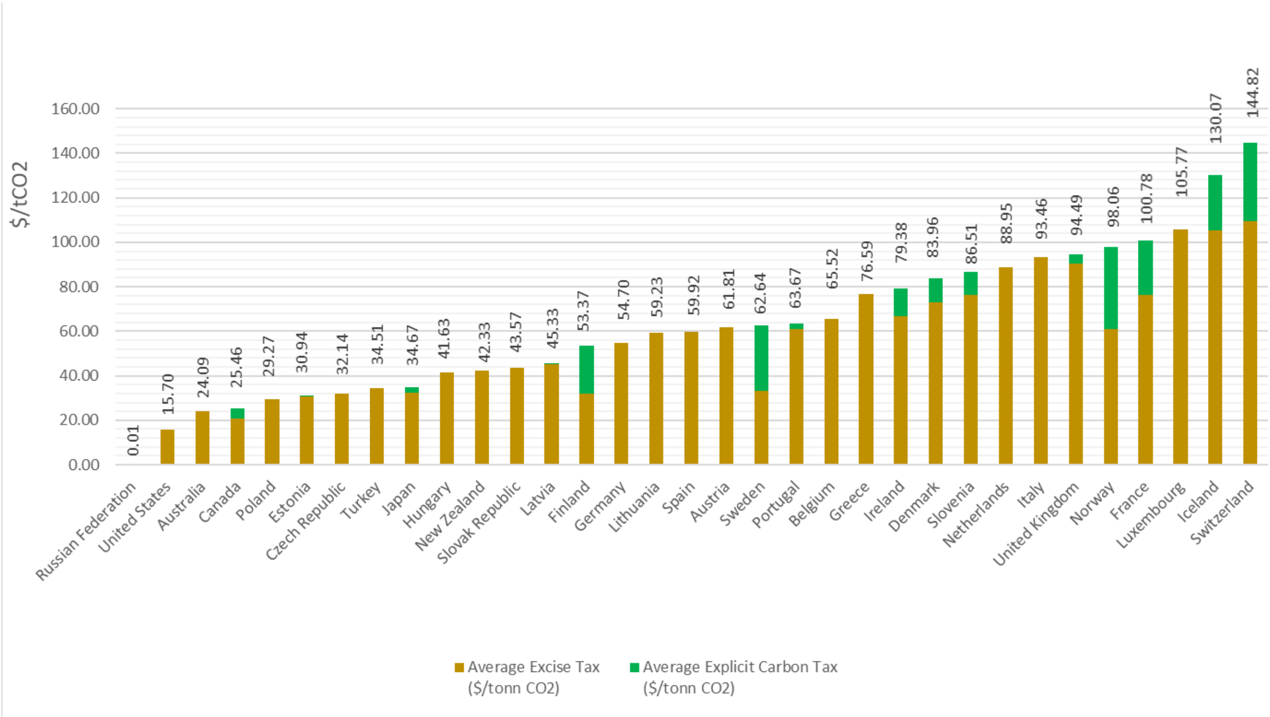
fuel excise tax data, since they follow the same calculations. The OECD also provides detailed information on the amount of emissions covered by each tax rate, allowing for the computation of the following average carbon prices. While the OECD data does not include ETS allowance prices, we assumed that excluding ETS from the following analysis would not change the conclusion, that is, when fuel excise taxes are considered, they represent the highest share of carbon pricing within a country. Emission Trading Systems cover approximately 10% of global GHG emissions across all economic sectors. The EU ETS alone accounts for more than 4% of it. As mentioned before in this chapter, other major emitting countries do not have a national ETS (World Bank, 2020).

Average carbon prices provide an understanding of the level of carbon pricing for all of the countries' energy-related emissions. However, country averages do not give indications as to the variations of the carbon rate within a country, nor do they show which portions of emissions are priced at various rates (OECD 2018b).

Figures 2.1, 2.2 and 2.3 show that fuel excise represented the largest share of carbon pricing in 2018 for all countries taken into consideration. Also, the figures corroborate the above conclusion: major emitter countries have carbon price levels that are below $60, even when excise taxes are considered, with the exception of a few European countries.

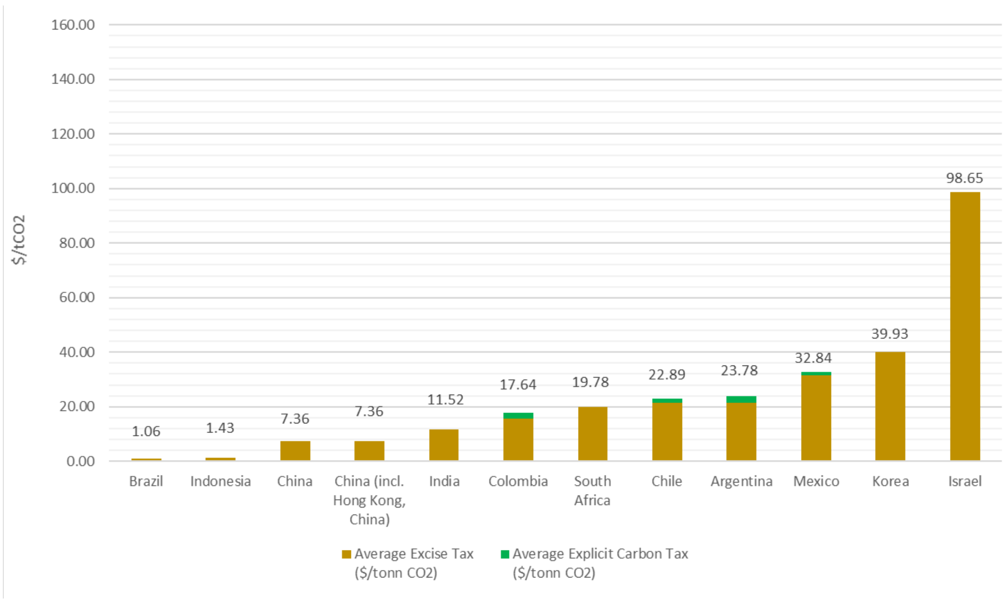
In the following graphs, countries are divided into three groups: the first group (fig. 2.1) comprises countries included in UNFCCC Annex 1[14]; the second group (fig. 2.2) comprises Non-Annex 1 countries that belong either to the OECD or to the G20; the third group (fig. 2.3) includes 15 developing countries that are neither G20 nor OECD members.

[14]UNFCCC country classification: https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states.



Source: Authors' own elaboration of OECD (2019) data[15]

Figure 2.2: Average carbon price (excluding ETS) in non-Annex 1 countries which are either members of the G20 or of the OECD (2018)

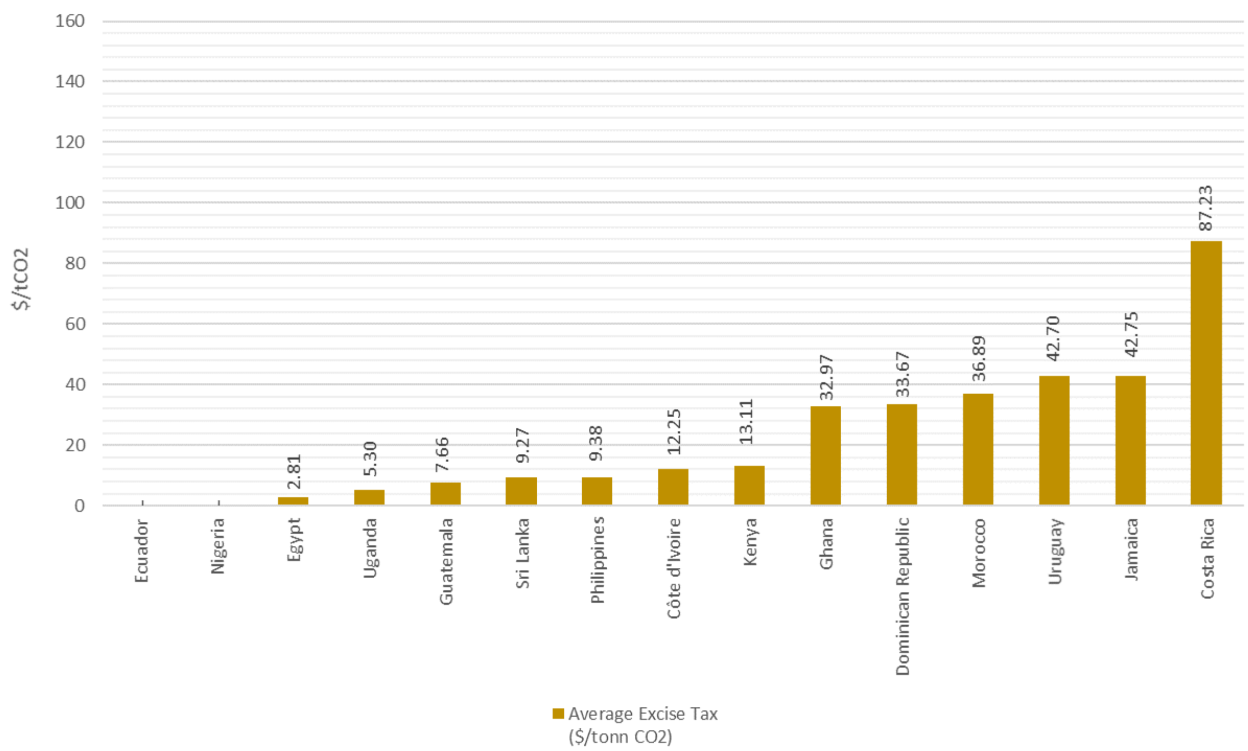


Source: Authors' own elaboration of OECD (2019) data[15]

Figure 2.3: Average carbon price (excluding ETS) in non-Annex 1 countries

[15] Note: To find the average excise tax of a country, first the various tax rates for each sector were multiplied by the emissions from the relative sector. The result of this operation is the revenue from fuel excise tax in that country. The fuel excise tax revenue was then divided by the country's total emissions from energy use. The same for the average carbon tax. In this way, we found the average carbon tax and fuel excise tax of each country. The graphs show the average carbon pricing as the sum of the average carbon tax and average excise tax. Data in EUR were converted in USD with the average 2018 exchange rate provided by the ECB: 1,181.

which are neither part of G20 or of OECD (2018)



Source: Authors' own elaboration of OECD Stats (2021c) data.

Next, the carbon price levels shown in the figures above are compared with a benchmark price of $60/tCO_2$. The $60 price level, used by the OECD in some analyses, is a middle-point price in the $ 40-80/tCO_2 range proposed by the High-Level Commission on Carbon Prices (see table. 2.1).

Among Annex 1 countries, most European countries are close or above the $ 60/tCO_2 benchmark. The US' average carbon pricing was $15.70/$tCO_2$, while Japan had a far higher level of $ 34.67tCO_2. Conversely, Russia stands close to 0 ($ 0.01/tCO_2). However, the OECD analysis of 2021 puts Russia's CPS_{60} at 7%.

Among European countries, the largest emitters are close or above the $60 level, with Germany reaching $ 54.70/tCO_2, the UK $ 94.49, Italy $ 93.46 and France $ 100.78.

Looking at the countries in figure 2.2, the highest results are in Israel ($ 98.65 the only country outside Europe to reach an average carbon price above 60 EUR), Korea ($ 39.93) and Mexico ($ 32.84). The highest emitters present lower results, with China reaching $ 7.36/tCO_2 and India $ 11.52.

The OECD (2021d) studied the fossil fuel taxes of the 15 countries of figure 2.3 because they had shown an initial interest in energy tax and fossil fuel subsidy reform. These countries do not have a carbon tax, so the carbon pricing reflects just the fuel excise tax, which is typically only applied to certain fuels, e.g., gasoline used for road transport (OECD, 2021d).

Countries in figure 2.3 form a heterogeneous group, sharing the need to increase energy access, (whereas OECD countries mostly need to maintain universal access). In this context, "fossil fuels used for heating, cooking and lighting are often taxed at lower rates or subsidized. Raising rates on these fuels requires particular caution because of an elevated risk of unintended side effects, e.g., charcoal-switching that could worsen health; environmental and fiscal outcomes. In addition, affordability is a prime concern" (OECD, 2021d:16).

Their main source of energy-related CO_2 emissions in countries of figure 2.3 is biofuel use, primary solid biofuels and charcoal, accounting in average for 45.5% of energy-related CO_2 emissions. In OECD countries biofuel use accounts, on average, for 18.5% of energy-related CO_2 emissions (OECD, 2021d).

PART THREE – Decarbonization path and carbon pricing

Part Three discusses the impact of various sectors on emissions from energy use and carbon pricing revenues, highlighting their respective characteristics. Furthermore, it shows the relationship between carbon pricing mechanisms and methods to reduce the carbon intensity of the GDP.

Main findings are:

- The “ROAD SECTOR” presents higher levels of carbon pricing but lower levels of carbon emissions from energy use compared to “ALL OTHER SECTORS”. Conversely, “ALL OTHER SECTORS” present lower levels of carbon pricing but are responsible for the highest share of emissions. As a result, the "ROAD SECTOR" contributes more to carbon pricing revenues.
- Countries with higher carbon pricing are further ahead in the decarbonization of their economies, proven by their low values of carbon intensity of GDP.
- In recent decades, countries have made significant progress in reducing the energy intensity of their GDP and carbon intensity of energy, mainly cutting down the former. Carbon pricing thus proves to be a useful tool to abate carbon intensity of energy, fostering economies’ decarbonization.

3.1 Carbon emissions from energy use

Carbon emissions from energy use account for almost the total of global CO_2 emissions. We must urgently reverse the current situation, where the lion’s share of global emissions is unpriced. Pricing carbon emissions promotes infra & intergenerational equity and strengthens countries’ capacity for decarbonization. Levelling global carbon pricing supports these objectives, while leaving countries the flexibility to choose their best fitting carbon pricing policies.

Moreover, levelling carbon pricing constitutes a global instrument that can raise financial resources and public funds, support the development of green and sustainable finance, and actions for climate change mitigation and adaptation.

Figures 3.1 and 3.2 show CO_2 emissions from energy use by the following five selected economies, which together account for more than two-thirds of global emissions:

- EU-27 (21 EU and OECD Countries accounting for more than 97% of EU GDP;
- China;
- India;
- United States;
- Japan.

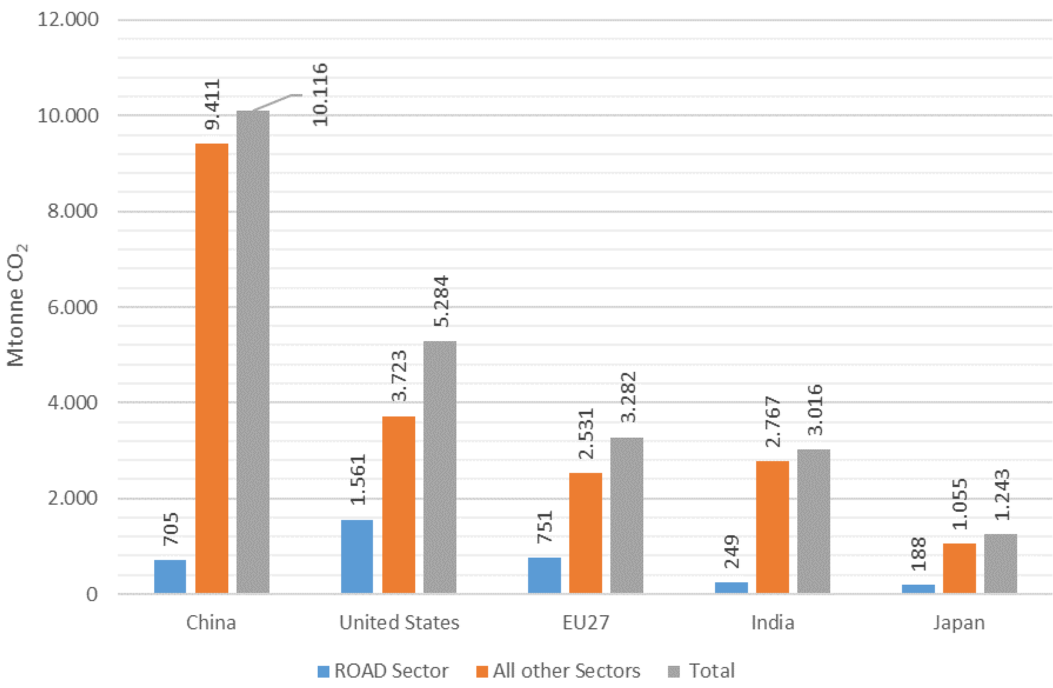
To highlight the different impacts of sectors in terms of emissions and carbon pricing revenues, emission data have been organized into two main sets:

1. “ROAD SECTOR” carbon emissions from energy use;
2. “ALL OTHER SECTORS” carbon emissions from energy use. According to the OECD (2019) definition, “ALL OTHER SECTORS” includes “Off road”, “Industry”, “Agriculture & Fisheries”, “Residential & Commercial” and “Electricity” sectors.

First, China's share of total carbon emissions from energy use almost doubles that of the United States' and triples that of the EU-27 or India's carbon emissions share (Figure 3.1). China's emissions are eight times higher than Japanese emissions.

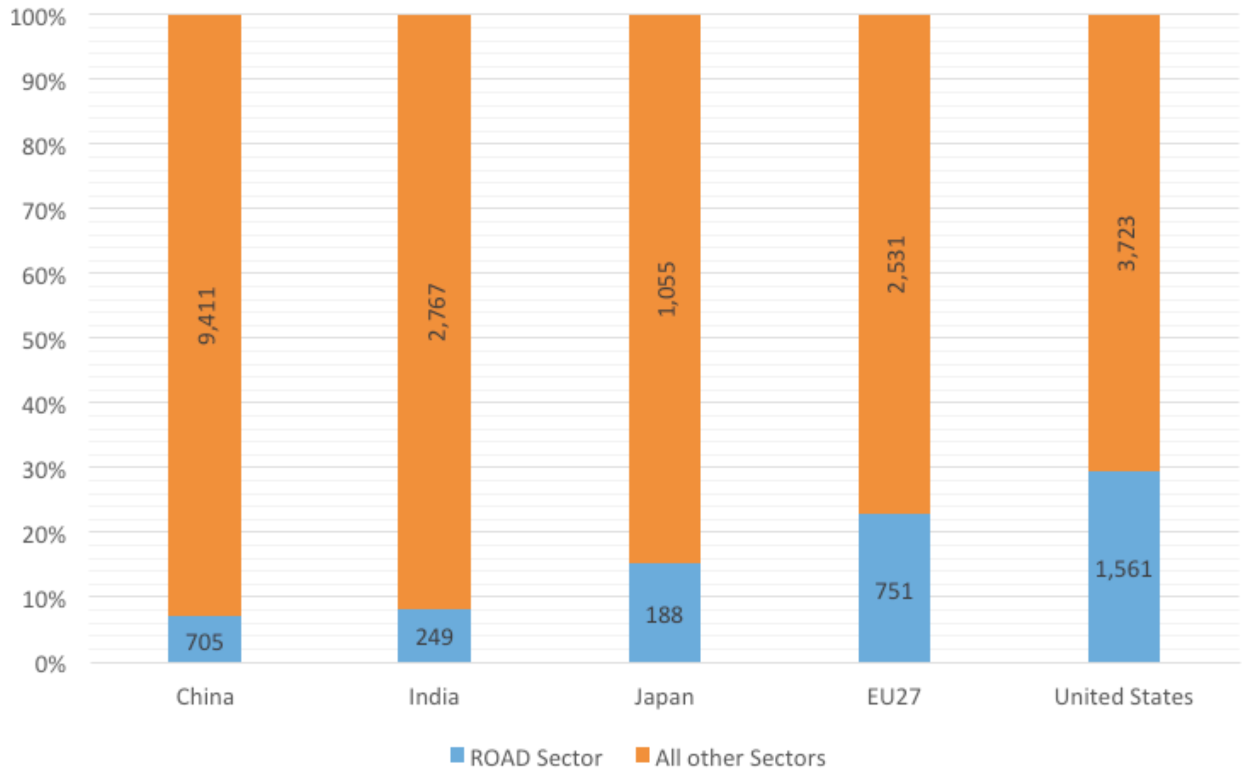
Moreover, the emissions from the "ROAD SECTOR" represent a variable share of total emissions. It is always less than 30% of the total carbon emissions from energy use: this share accounts, respectively, for about 7% and 8% in China and India, doubling to 15% in Japan and rising up to 23% in EU-27 and 30% in the United States (figure 3.2).

Figure 3.1: Carbon emissions from energy use (2018)



Source: Author's own elaboration of OECD (2019) data

Figure 3.2: Carbon emissions from energy use (%, 2018)



Values in the columns correspond to $MtCO_2$, as shown in figure 3.1

Source: Author's own elaboration of OECD (2019) data

In conclusion, both in absolute and in percentage values, "ALL OTHER SECTORS" are responsible for the greater share of carbon emissions from energy use. The “ROAD SECTOR” emissions represent percentages ranging from less than 10% of total emissions from energy use (India and China) to 30% (United States).

3.2 Carbon pricing revenues and differences across sectors

As illustrated in Part One, across different carbon pricing mechanisms, carbon pricing is the sum of three addenda:

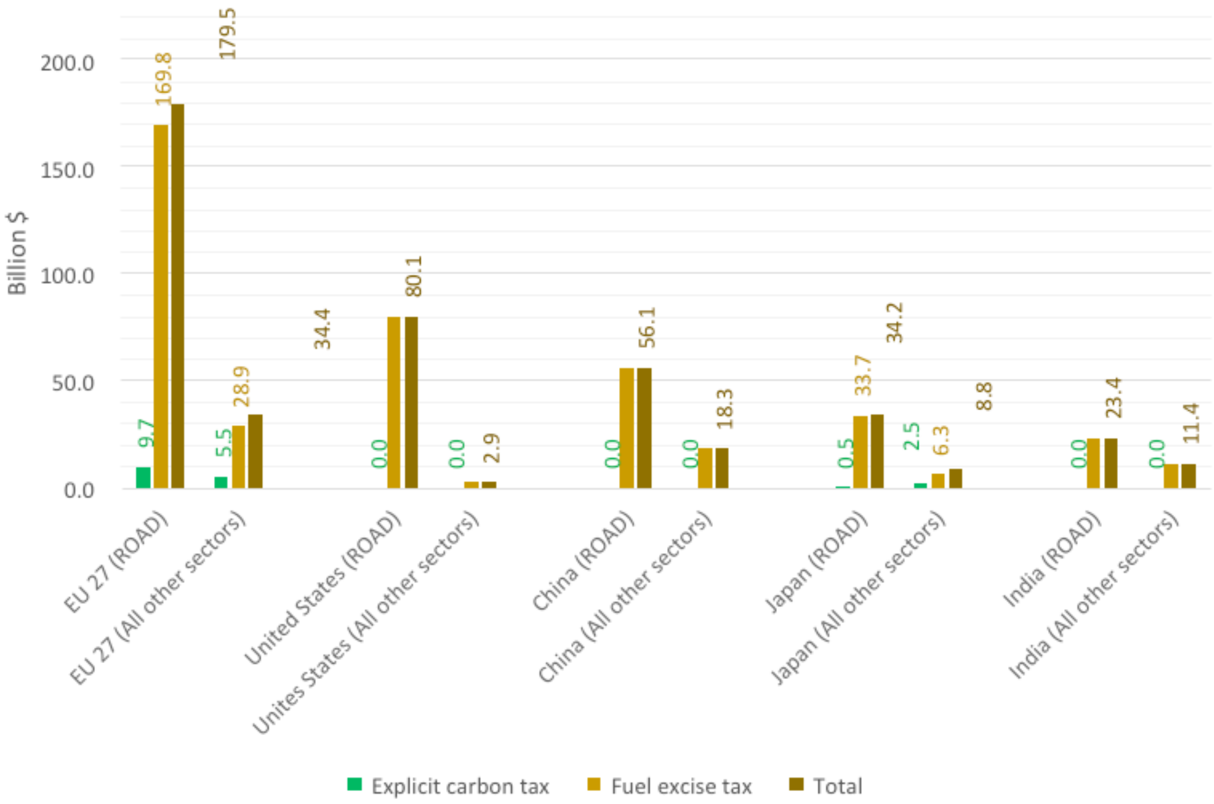
- Explicit carbon tax (whose rate is explicitly related to the carbon content of the fuel).
- Specific tax on energy use (especially fuel excise taxes, which are levied on fuels and are not carbon taxes).
- Emission Permit Price (price of tradable emissions permits, also called emissions allowances, regardless of the permit allocation method, representing the opportunity cost of emitting an extra unit of CO_2).

Figure 3.3 provides an overview of carbon pricing by energy use for the same group of countries and sectors considered above for the carbon emission analysis. Based on the available data (OECD, 2019), due to a lack of homogeneity of the Emission Permit Price[16] and their low share in the total carbon price, only "explicit carbon taxes" and "fuel excise taxes" have been taken into account for the following carbon pricing evaluation.

As shown in Figure 3.3, the selected economies vary in their capacity to obtain revenues through carbon pricing: EU-27 carbon pricing revenues reach $ 213.8 billion[17]; United States follows with $ 83 billion and China with $ 74.4 billion.

The "Fuel excise tax" fully dominates carbon pricing revenues: it accounts for 100% in China, India and the United States. In the European Union and Japan "Fuel excise tax" accounts for 92.9%, while 7.1% comes through "explicit carbon tax" revenues.

Figure 3.3: Carbon pricing revenues from energy use emissions (2018)



Source: Author's own elaboration of OECD (2019) data

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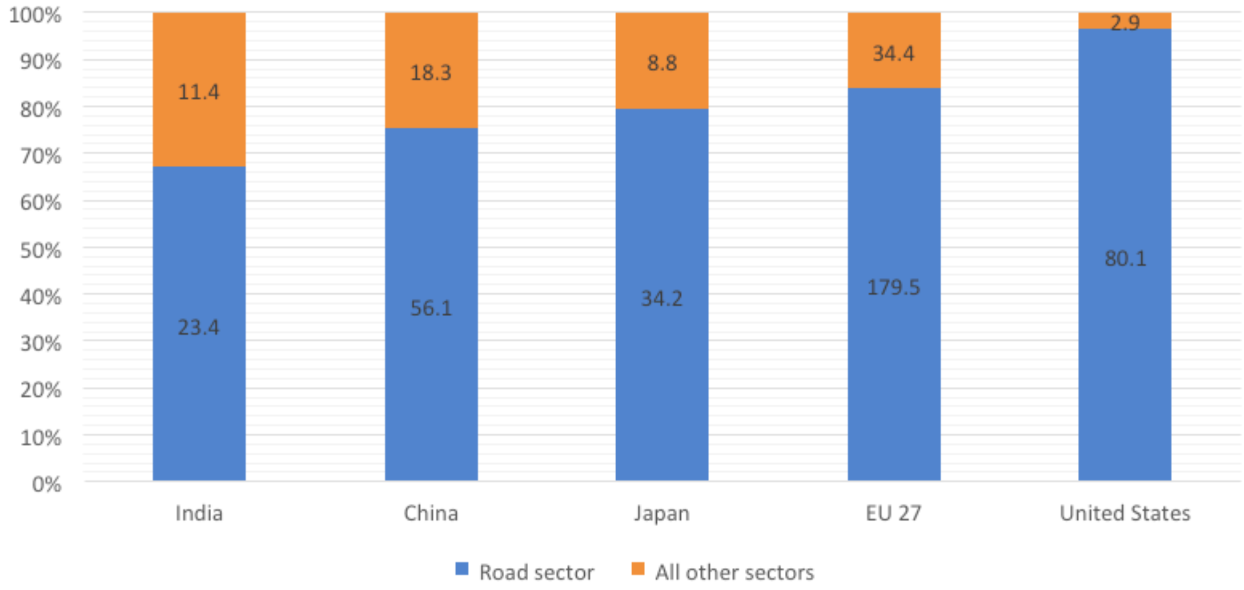
[16] Based on data from the World Bank (2021) for 2018, we estimated that the ETS of 21 of these countries covered together 5.2 Gt CO_2 eq, corresponding to 9.6% of global GHG emissions across all economic sectors. Data on ETS are also not very homogeneous and sometimes refer to pilot projects or sub-national schemes; therefore, data are not very suitable for generalizations, national estimates and comparison among countries. For these reasons, carbon pricing revenues resulting from ETS have been excluded from the analysis.

[17] For the EUR-US dollar conversion, the average exchange rate for the year 2018 equalling 1.181 US dollars per Euro was used.

Carbon pricing of the "ROAD SECTOR" represents the largest part of total carbon pricing: it accounts for 67% in India and 97% in the United States, while in China, Japan and EU-27, carbon pricing of the "ROAD SECTOR" represents 75%, 79% and 84% respectively (Figure 3.4). Carbon emissions distribution across the ROAD SECTORs of these countries shows a reversed situation, since "ALL OTHER SECTORS" contribute the most to emissions in all the countries and region selected (Figure 3.2).

The "ROAD SECTOR", which accounts for the smallest part of carbon emissions compared to "ALL OTHER SECTORS", is the most carbon priced sector. In other words, the "ROAD SECTOR" contributes less to overall emissions from energy use. Still, it weighs heavily on carbon pricing revenues in comparison with – and opposition to – "ALL OTHER SECTORS".

Figure 3.4: Carbon pricing revenues from energy use emissions (%, 2018)



Values in the columns correspond to $ billions, as shown in Figure 3.3

Source: Author's own elaboration of OECD (2019) data

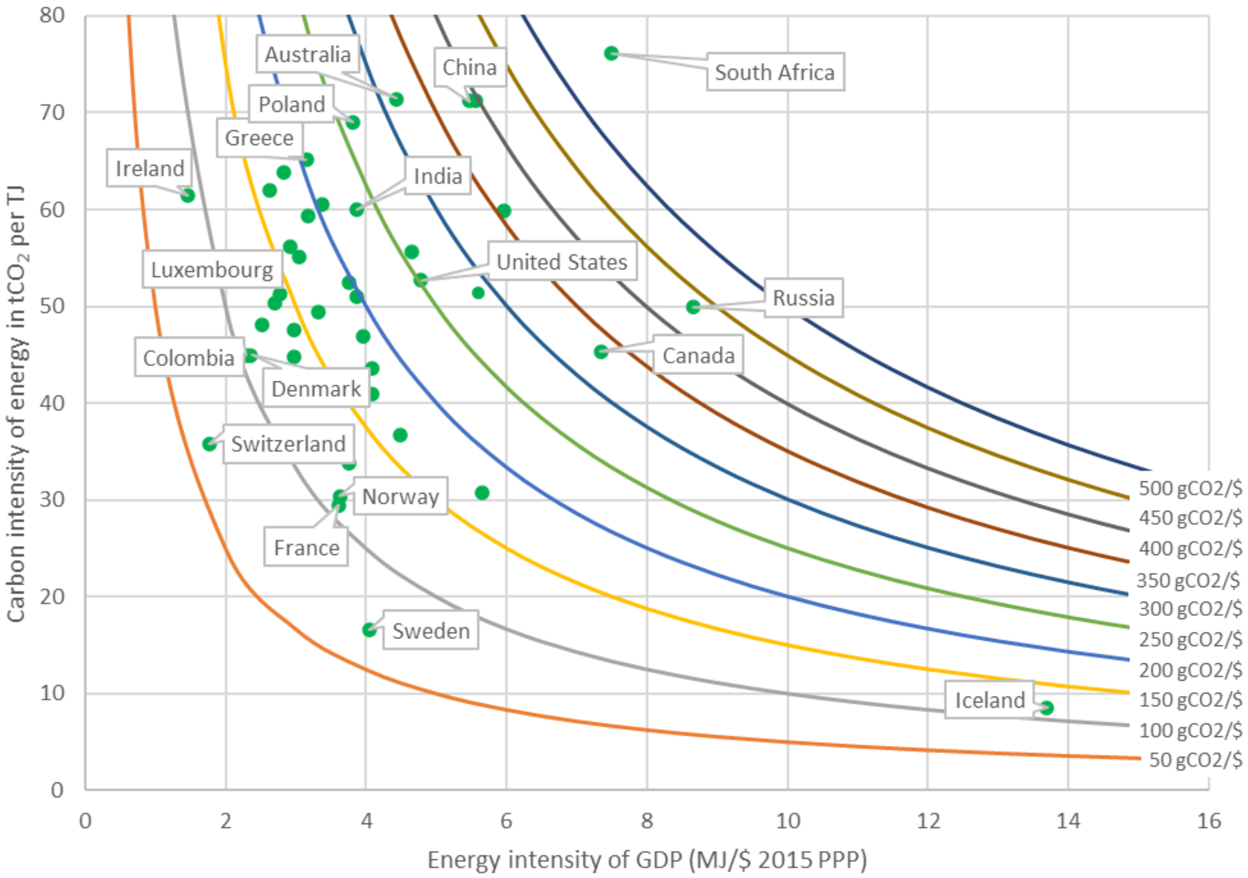
3.3 Decarbonizing economies by levelling carbon pricing in countries

The following paragraphs illustrate how countries with higher overall carbon pricing lead to a decarbonization of their economies. The following Figures 3.5, 3.6 and 3.7 couple IEA data regarding carbon intensity of GDP and OECD with the average carbon pricing by countries ($ / tCO_2). The energy intensity of GDP (MJ / $ 2015 PPP) is represented on the horizontal x-axis, while the carbon intensity of energy (tCO_2 / TJ) is represented on the vertical y-axis.

Going into greater detail in the analysis and results obtained for the countries listed in Annex A, the highest carbon intensity of energy values was measured in South Africa, Australia, China, Poland

and Greece, ranging between 65 and 76 tCO_2 / TJ, while the lowest carbon intensity of energy was measured in Iceland (8.5 tCO_2 / TJ) and Sweden (16.56 tCO_2 / TJ).

Figure 3.5: Carbon intensity of energy and energy intensity of GDP (2018)



Source: Author's own elaboration of IEA (2020)

Regarding the energy intensity of GDP, the highest values were recorded in Iceland (13.7 MJ / $ PPP), Russia (8.65 MJ / $ PPP), South Africa (7.50 MJ / $ PPP) and Canada (7.34 MJ / $ PPP). Conversely, Ireland, Switzerland, Colombia, Denmark and Luxembourg (all ranging between 1.46 and 2.5 MJ / $ PPP) have the lowest energy intensity of GDP values.

Data within the diagram measure the carbon intensity of GDP in 2018: the carbon intensity of GDP $\left(\frac{CO2\ emissions}{GDP}\right)$ is the result of multiplying the carbon intensity of energy $\left(\frac{CO2\ emissions}{energy\ use}\right)$ by the energy intensity of GDP $\left(\frac{energy\ use}{GDP}\right)$.

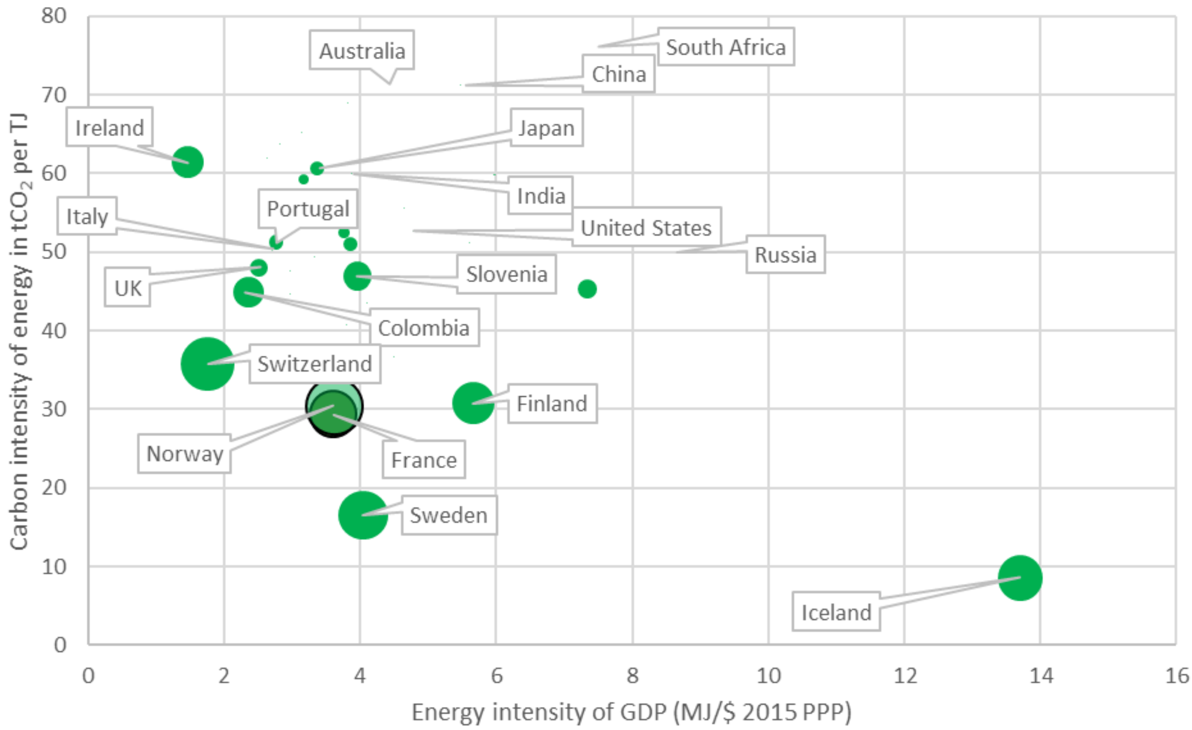
Figure 3.5 shows that countries with the highest carbon intensity of GDP are South Africa (0.57 kg CO_2 / $ PPP), Russia (0.43 kg CO_2 / $ PPP) and China (0.40 kg CO_2 / $ PPP) while Switzerland and Sweden (both 0.06 kg CO_2 / $ PPP), and Ireland (0.09 kg CO_2 / $ PPP) have the least carbon intensity of GDP.

"Iso-carbon" lines show equal values for the carbon intensity of GDP. The carbon intensity of GDP decreases towards the origin of the axis; lower values of the "iso-carbon" line are closer to the origin/axes and imply lower carbon intensity of GDP value.

Decarbonization goals require that climate neutrality (set at 2050 for the European Union and 2060 for China), i.e., net-zero emissions of greenhouse gases, should be reached in the coming decades. Net-zero emissions imply that either the carbon intensity of energy or the energy intensity of GDP – or both together – should shift to zero. As highlighted by the OECD, despite necessary energy efficiency and energy reduction policies, it would seem difficult for energy intensities of GDP to decline towards zero. Thus, for economies to decarbonize, countries need to move vertically towards the x-axis, reducing their carbon intensity of energy.

Figure 3.6 aligns the carbon intensity of GDP with the average explicit carbon tax rate[18] (\$ / tCO_2). It shows that countries having a smaller – or null – average explicit carbon tax rate (shown by small or null bubble diameter) are farther from the axis/origin of the diagram. It highlights that they are set back in decarbonizing their economies and have higher values of the carbon intensity of their GDPs. Conversely, countries with a high explicit carbon tax tend to have a low carbon intensity of GDP and to be more carbon-efficient.

Figure 3.6: Carbon intensity of GDP and average explicit carbon tax rate (2018)



Source: Author's own elaboration of OECD (2019) and IEA (2020) data

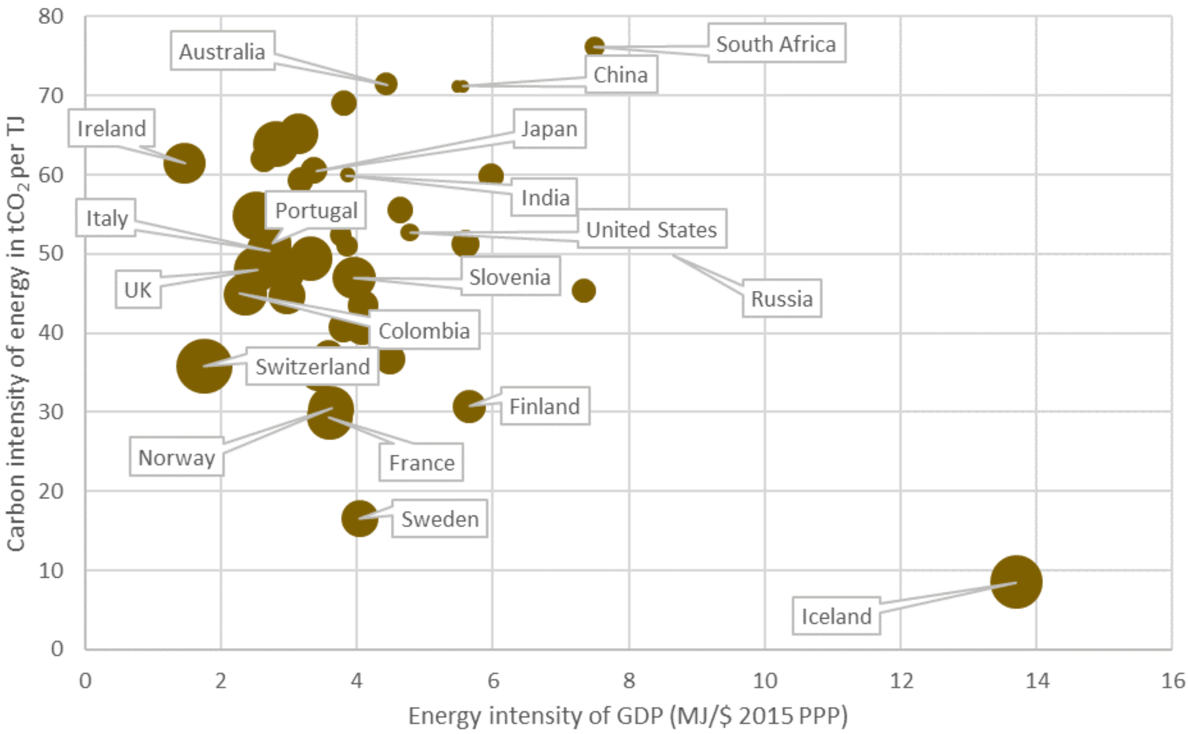
Note: bubble sizes indicate the average explicit carbon tax rate consistency.
The more a country is closer to the axis/origin of the diagram, the lower its carbon intensity of GDP (product of "Carbon intensity of energy" by "Energy intensity of GDP"). For each country, the average explicit carbon tax rate is the ratio between the total amount of explicit carbon tax for all sectors and the total amount of CO_2 emissions (for all sectors).

[18] The average explicit carbon tax rate is calculated as the ratio between the total revenue from "explicit carbon tax" and the total CO_2 emissions by energy use.

Carbon pricing raises the price of carbon-intensive energy. It encourages agents to switch to a more carbon-efficient energy mix, moving up-to-down with respect to the horizontal axis (x-axis) of the graph. At the same time, carbon pricing, increasing the price of the carbon content of energy, increases energy prices and encourages energy savings, moving right-to-left with respect to the vertical axis (y-axis).

These findings are confirmed and reinforced by adding and including the specific tax on energy use in carbon pricing. Using the average carbon rate[19] ($ / tCO_2) for the countries listed in Annex A, Figure 3.7 gives similar results to the ones shown in Figure 3.6 (bubbles increase in number and size because, as seen previously, "fuel excise taxes" are much higher than the "explicit carbon taxes", which are null in many countries).

Figure 3.7: Carbon intensity of GDP and average carbon rate (2018)



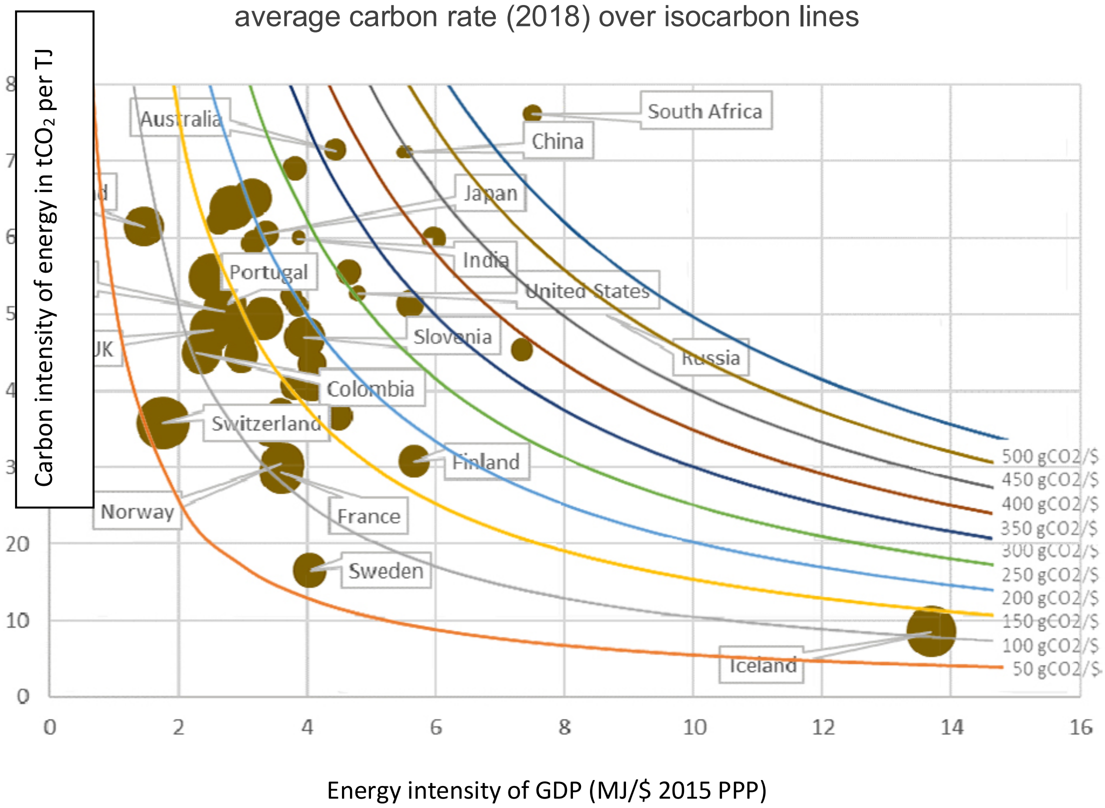
Source: Author's own elaboration of OECD (2019) and IEA (2020) data

Note: bubble sizes reflect the average carbon rate.
The more a country is closer to the axis/origin of the diagram, the lower its carbon intensity of GDP (product of "Carbon intensity of energy" by "Energy intensity of GDP"). For each country, the average carbon rate is the ratio between the total amount of carbon pricing (explicit carbon tax plus fuel excise tax) for all sectors and the total amount of CO_2 emission (for all sectors).

The following picture will immediately show the link between low carbon intensity of GDP (country carbon-efficiency) joining together the isocarbon lines (see fig. 3.5) and the "average

[19] The average carbon rate is calculated as the ratio between the total revenue from the explicit carbon tax and fuel excise tax and the total CO_2 emissions by energy use.

carbon rates" values (see bubbles diameters in fig. 3.7).Figure 3.8: Carbon intensity of GDP and average carbon rate (2018) over isocarbon lines



Source: Author's own elaboration of OECD (2019) and IEA (2020) data

The following table shows some numeric values shown in Figures 3.7 and 3.8.

AVERAGE CARBON PRICING AND CARBON INTENSITY OF GDP (2018)

Country (2018)	***Average Carbon Pricing (all sectors) (explicit carbon tax + fuel excise tax) (USD/tonn CO2)*** *Source: OECD 2019*	***Carbon intensity of GDP (grCO2 / USD 2015 PPP)*** *Source: IEA CO2 Highlights 2020*
Switzerland	$144.82	63
Sweden	$62.64	67
Ireland	$79.38	90
France	$100.78	106
Iceland	$130.07	117
Italy	$93.46	136
Germany	$54.70	168
EU	$65.11 *(EU 22 OECD countries)*	149 *(EU 28)*
United States	$15.70	252
Australia	$24.09	317
Canada	$25.46	333

China	$7.36	396
Russian Federation	$0.0053	432
South Africa	$19.78	571

Notes

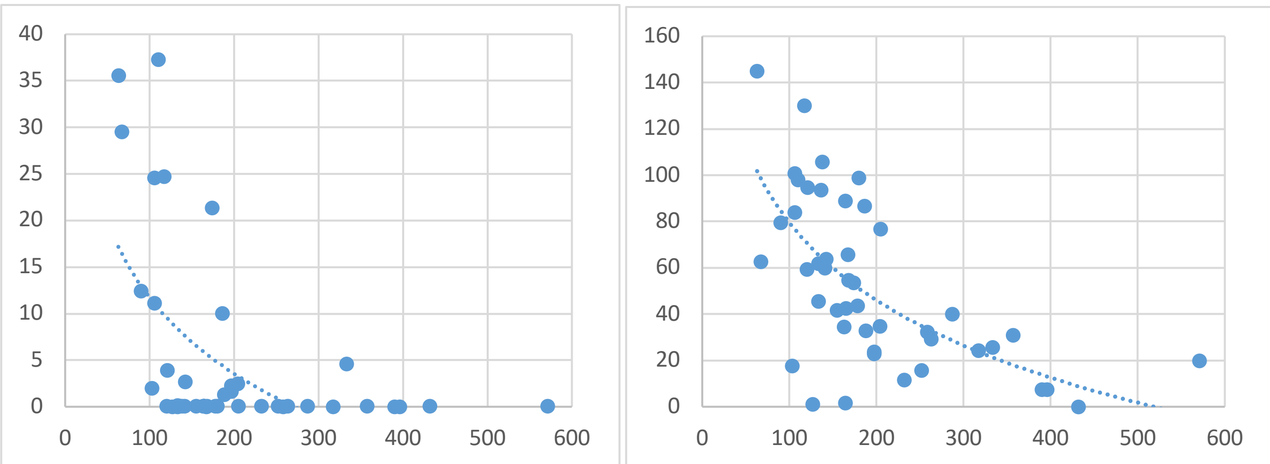
In 2018, emission covered by ETS amounts to around 9,6% of total.

Globally, in 2020, carbon prices from the ETS and carbon taxes ranged from less than US$ 1/t CO_2e to US$ 119/tCO_2e, with almost half of the covered emissions priced at less than US$ 10/tCO_2e. Among the emissions under a carbon tax or an ETS, less than 5% are in line with the estimated $ 40-80/tCO_2 2020 price range (World Bank, 2020).

In 2021, the price of EU ETS allowances has surpassed $40/t$CO_2$ (ICAP, 2021b).
Among the largest emitters, the US, India and Russia, did not have a national carbon tax or ETS instrument by 2020. China is starting its national ETS in 2021. Sub-national ETS have been implemented in China and in the US, but their prices are below the $40-80 / t$CO_2$ range. The same is true for Japan (World Bank, 2021).

Figure 3.9 shows that both the "average explicit carbon tax rate" and the "average carbon rate" [20]have a negative correlation with the carbon intensity of GDP: thus, the higher the carbon pricing, the more advanced the country is in its decarbonization.

Figure 3.9: Carbon intensity of GDP and carbon pricing (2018)



Source: Author's own elaboration of OECD (2019) and IEA (2020) data

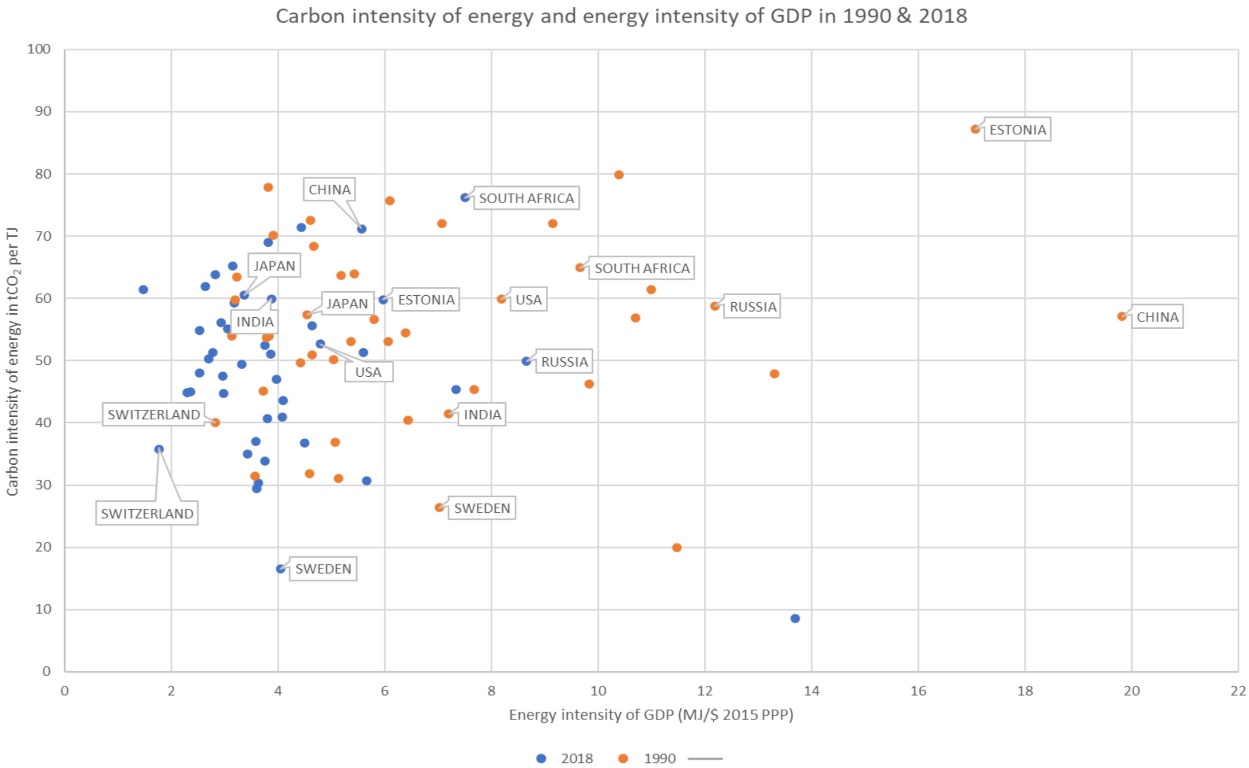
Note: the correlation coefficient between carbon intensity of GDP and carbon pricing is equal to -0.41 when considering the "average explicit carbon tax rate" (Figure 3.9, left) and grows to -0.59 when relating to the "average carbon rate"(Figure 3.9, right). Therefore, the correlation increases when implicit forms of carbon pricing are included.

[20] See footnote 19.

It could be inferred that countries that increase and broaden carbon pricing could also move closer to the axis/origin. Carbon pricing could be broadened if it is first expanded to "ALL OTHER SECTORS" emissions from energy use. This approach would contribute to level carbon prices among sectors, considering that the "ROAD" sector faces higher carbon prices.

Regarding advancements in decarbonization, between 1990 and 2018, Figure 3.9 shows that the group of selected countries has made significant progress. They moved closer to the origin of the axes, mainly improving their efficiency in terms of energy intensity of GDP (moving right-to-left with respect to the vertical y-axis). Much progress has been achieved , but more efforts – also using carbon pricing – must be done.

Figure 3.9: Carbon intensity of energy and energy intensity of GDP (1990, 2018)



Source: Author's own elaboration of IEA data (2020)

PART FOUR – Fossil fuel subsidies

As stated in Part One, fossil fuel subsidies reduce the price of carbon, working as an implicit negative carbon pricing, and thus hindering the path towards energy transition. This chapter presents fossil fuel subsidy analysis and discusses the importance of carbon pricing in reducing emissions even in a scenario in which fossil fuel subsidies are removed.

Main findings:

- Subsidies remain a significant cause of the low cost of fossil fuels. According to a joint estimate by the OECD and the IEA, fossil fuel subsidies amounted to $ 467.7 billion in 2019. Both the gradual removal of fossil fuel subsidies and carbon pricing contribute to the same objective of encouraging the use of less polluting forms of energy.

- From a global perspective, removing fossil fuel subsidies alone would reduce CO_2 emissions by less than what countries have committed to in their NDCs. Therefore, removing fossil fuel subsidies is necessary, but not sufficient, to reduce GHG emissions as required by the Paris Agreement. Internalizing the cost of the negative externalities of fossil fuels in their price is key to reducing the carbon intensity of global economies.

4.1 Global fossil fuel subsidies - estimates

There is a lack of an established definition for "subsidy", which makes the assessment of public support and cross-country comparisons difficult. Among international organizations, the OECD, the IEA, and the IMF have collected data on fossil fuel subsidies systematically, but with different methodologies (European Union, 2017) and different country coverage.

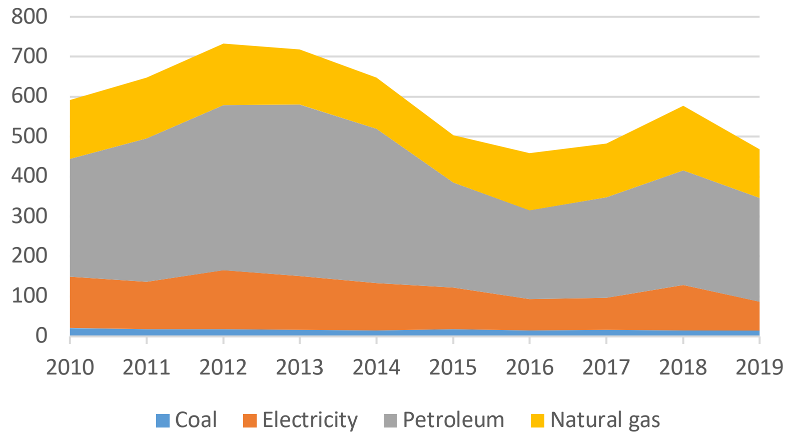
As a result, subsidy' estimates among these organizations usually differ significantly. This is due mainly to the exclusion or inclusion of the negative externalities in the computation of subsidy levels. The IMF calculates *post-tax* subsidies that include externalities and *pre-tax* subsidies that do not include them. Diversely, the OECD and IEA do not include externalities in their computation.

The gap between estimates is so deep that, if externalities are excluded coal would prove to be the least subsidized fuel product (as the OECD-IEA estimates show), while if externalities are included it would prove to be the most subsidized fuel (as shown by the IMF *post-tax* methodology). For this reason, the various methodologies accounting for fossil fuel subsidies must be taken into consideration to provide a broader understanding of the current situation. The current paragraph specifically addresses this issue.

Fossil fuel subsidies level according to OECD-IEA and the "IMF pre-tax" methodology

The OECD and the IEA produced a joint estimation of fossil fuel subsidies worldwide. They reconciled their estimates, worked through overlaps and discrepancies providing aggregated fossil fuel support data for 81 countries[21] from 2010 to 2019 by energy product, presented in Figure 4.1 (OECD, 2021a). In 2019, fossil fuels support measures amounted to $ 467.7 billion; in 2017, the total amount was $ 482.3 billion. In 2016 it was $ 458 billion, and in 2012 it was $ 733 billion.

Figure 4.1: Fossil Fuel support by energy product from 2010 to 2019 for **81 countries** (OECD-IEA combined estimates, 2019 $ billion)



Source: OECD (2021a)

Coal subsidies remained almost constant in the period observed and represented 4% or less of the total amount. Conversely, support measures for petroleum represented the highest share, from 60% (2014) to 49% (2017) of total subsidies (50% in 2019).

Oil subsidies have historically followed the level of oil prices, although part of the decrease in subsidies could also be a sign of subsidies reform (Jewell et al., 2018). The changes in the value of support measures for petroleum have driven the overall shift in subsidy values.

The electricity subsidies represented between 16% and 21% of the total (20% in 2019). Those for natural gas represented between 19% and 31% of the total (28% in 2019).

According to the OECD/IEA estimation, coal is the least subsidized fuel. However, the following paragraph will show how, instead, coal could be the *most* subsidized fuel, if subsidies covered environmental and other externalities.

Data in Figure 4.1 align OECD and IEA methodologies. The OECD considers as "support measures for fossil fuels" the direct budgetary transfers and tax expenditures that confer a benefit or preference for fossil-fuel production or consumption relative to alternatives (OECD, 2018a). The IEA compares

[21] The OECD uses the term "support measures for fossil fuels" in its analysis. We use "fossil fuel support", "support measures" and "subsidies" interchangeably. Countries covered in Figure 4.1 include OECD countries (Australia, Austria, Belgium, Canada, Chile, Colombia, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Sweden, Switzerland, Turkey, United Kingdom, United States); OECD partner economies and countries covered by the IEA: Angola, Argentina, Armenia, Azerbaijan, Algeria, Bangladesh, Bahrain, Belarus, Bolivia, Brunei Darussalam, Brazil, Chinese Taipei, Ecuador, Egypt, El Salvador, Gabon, Georgia, Ghana, Indonesia, India, Islamic Republic of Iran, Iraq, Kazakhstan, Kuwait, Libya, Malaysia, Moldova, Nigeria, Oman, Pakistan, People's Republic of China, Qatar, Russian Federation, Saudi Arabia, South Africa, Sri Lanka, Thailand, Turkmenistan, Trinidad and Tobago, Ukraine, United Arab Emirates, Uzbekistan, Venezuela, Viet Nam.

the end-use prices paid by fuel consumers with international reference prices (i.e., prices that would prevail in a competitive market). The difference between the consumer price and the reference price is the price gap, and subsidy removal would equal its elimination (IEA, 2021)[22].

One of the methodologies used by the IMF estimates the amount of *pre-tax* subsidies, calculated as the difference between the amount consumers actually pay for fuel use and the corresponding opportunity cost of supplying the fuel (IMF, 2019). According to the IMF's estimates for 191 countries, *pre-tax* subsidies composed $ 296 billion of total global subsidies in 2017, while they were $ 269 billion in 2016 and $ 572 billion in 2012 (IMF, 2019).

Fossil fuel subsidies level when externalities are considered

The IMF uses a second definition of subsidy, the "*post-tax* subsidy", for which the calculation methodology is remarkably different from those of the OECD and the IEA in estimating fossil fuel subsidies. This second methodology, in fact, includes the environmental externalities produced by fossil fuels in its subsidy calculations. Results from this methodology are important because, as methodology differs greatly, findings will also differ greatly, and can provide a broader understanding of subsidy size.

The IMF computes the subsidies as a "price-gap" between actual fossil fuel prices and a reference price, which includes the fossil fuel supply cost, environmental externalities, and consumption taxes as applied to other consumption goods in general[23] (IMF, 2019).

At the global level (considering 191 countries), energy subsidies were estimated by the IMF at $ 4.7 trillion in 2015 and $ 5.2 trillion in 2017, 10 times higher than the OECD/IEA estimate.

Table 2.1: 2017 subsidy values according to OECD/IEA and IMF($billion)

Organization	OECD/IEA (81 countries)	IMF Pre-tax (191 countries)	IMF Post-tax (191 countries)	IMF Total
Subsidy values in 2017 ($ billion)	482	296	4 904	5 200

Source: IMF (2019); OECD, (2021a)

[22] On the one hand, the IEA estimates paint a clear picture of "the magnitude of policies that reduce domestic fuel prices, hence subsidizing their consumption." (OECD, 2018:20). On the other hand, IEA data do not necessarily capture policies that support fossil fuels' production without directly affecting end-user prices; or policies that also confer benefits to consumers, such as direct budgetary transfers to consumers or reduced excise taxes" (OECD, 2018:21). Those measures are captured by OECD Inventory.

Combining the two datasets provides a single estimate of the magnitude of support for fossil fuels for both production and consumption. However, because IEA data do not capture support for producers of fossil fuels, the combined database would still be missing information on producer support for countries not covered by the OECD Inventory. (OECD, 2018) I.e., total final estimates and estimates for countries covered only by IEA data may be lower than actual subsidy values.

[23] The IMF compared actual and reference prices for 191 countries in 2015, for coal and natural gas use in power generation, gasoline, and road diesel. The difference between actual and reference prices is the fossil fuels' price gap, which, multiplied by the quantity of fuel consumption, gives the fossil fuel "subsidy" amount for those countries in 2015. The IMF 2019 paper shows details for 30 selected countries.

Concerning the disaggregation of subsidies by fuel product, according to the IMF post-tax methodology, coal is the most subsidized fuel, accounting for 44% of global subsidies in 2015. Petroleum accounted for 41%, natural gas for 10% and electricity for 4% in 2015 (IMF, 2019). The result is quite different from that of the OECD-IEA presented in Figure 4.1, in which coal was the least subsidized fuel.

According to the IMF, to be efficient, prices should include the supply cost, consumption taxes and the environmental costs - meant as a global warming cost (the cost of emissions), local air pollution costs and broader environmental costs of road fuels. Using such a methodology, 48% of subsidies would stem from under-pricing for local air pollution, while 24% from under-pricing for global warming (IMF, 2019). The calculation of the "global warming" component was done by using a carbon price of \$ 40/tCO_2 for 2015 emissions.

Considerations on the fossil fuel subsidy estimates

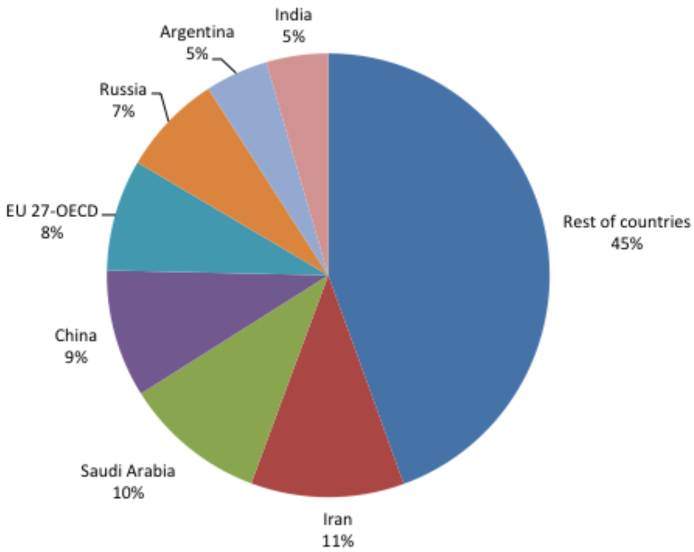
Fossil fuel subsidies do not support the internalization of climate change's negative effects. The IMF methodology of considering several environmental externalities as subsidies emphasize how much fossil fuel prices do not reflect these externalities. It serves as a reminder that estimates of CO_2 emissions, which consider only some climate change externalities, are an underestimation of all the costs associated with fossil fuel use. For example, when local air pollution externalities are considered – as in the IMF *post-tax* subsidies methodology – coal is the most subsidized fuel, while without considering these externalities – as in the OECD-IEA methodology – it is the least subsidized.

However, the OECD and IEA approach to subsidies (understood as government support for the consumption or production of fossil fuels that lowers their prices below normal market prices) is more consolidated. It can draw information from databases of multiple years and, consequently, is more widely used. For these characteristics, we will follow this approach, but also take into account the IMF's results as a reminder that fossil fuel externalities and cost go beyond climate change.

4.2 Fossil fuel subsidies across countries

Regarding disaggregated subsidy data by country, the most extensive coverage completed by the OECD is from 2015. The data covers 76 economies (OECD Stats, 2019), responsible for 93% of global emissions from fossil fuel combustion (Authors' computation based on data by IEA, 2020)

Figure 4.2: Contribution (%) of selected economies to the total value of fossil fuel subsidies in 76[24] countries in 2015 ($ 467 billion).



Source: Authors' own elaboration of data from OECD Stats (2019)

Figure 4.2 shows the contribution of selected economies to the total fossil fuel subsidies value reached by 76 countries in 2015. The countries or group of countries pictured in Figure 4.2 were those that represented 5% or more of total subsidies in 2015. Together, 7 economies added up to 56% of world subsidies in 2015.

From the economies in the "Rest of countries" category, Brazil, Indonesia and Venezuela reached 4% of total subsidies each; Algeria, Egypt and Italy reached 3%; Mexico, the United Kingdom, the United States and the United Arab Emirates reached 2% of total subsidies. Other countries remained below 2%.

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[24] Countries covered in Figure 4.2:

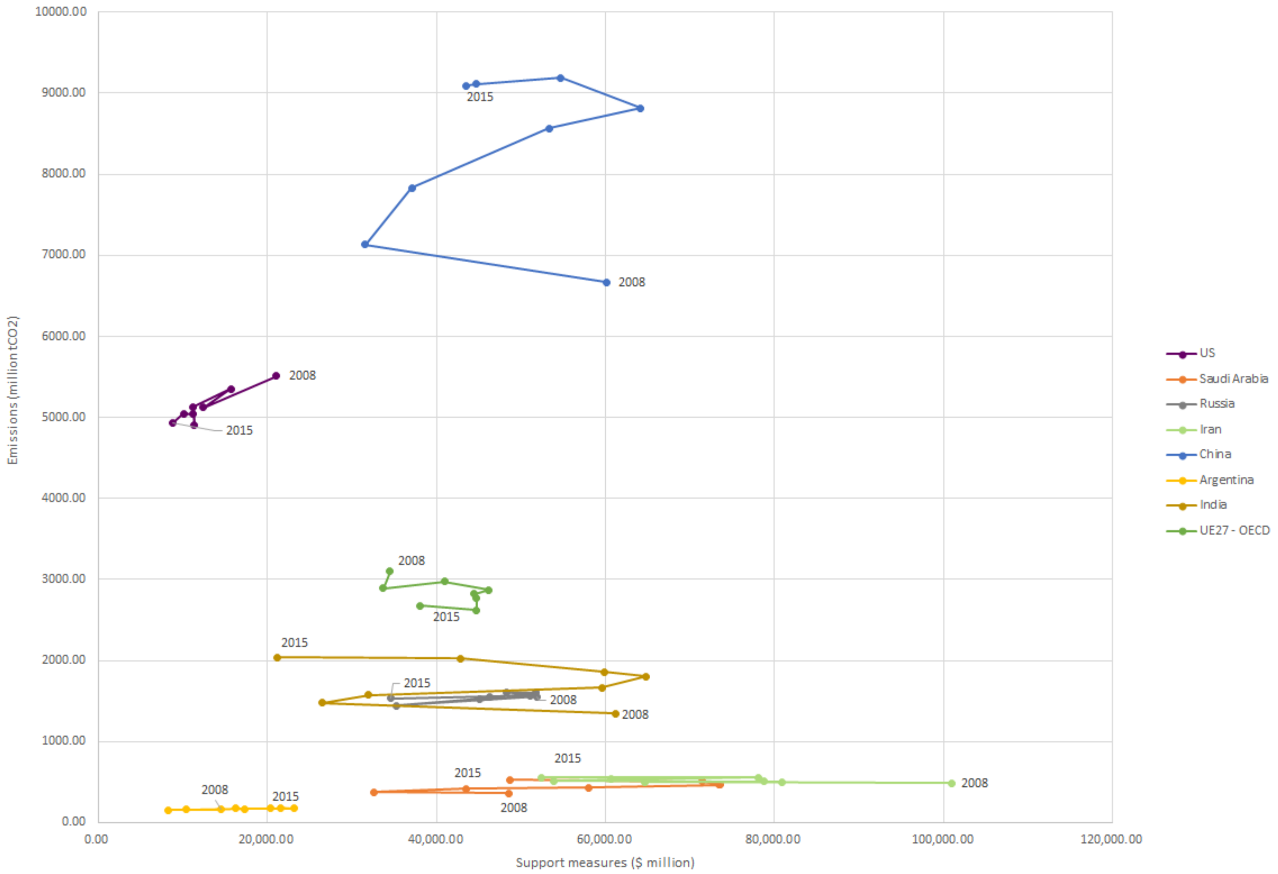
EU 27- OECD group are countries which belong both to OECD and EU 27, covered by the dataset: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden.

Other OECD countries: Australia, Canada, Chile, Colombia, Iceland, Israel, Japan, Korea, Mexico, Norway, New Zealand, Switzerland, Turkey, United Kingdom, United States.

Non OECD countries: Algeria, Angola, Argentina, Azerbaijan, Bahrain, Bangladesh, Bolivia, Brazil, Brunei Darussalam, China, Ecuador, Egypt, El Salvador, Gabon, Ghana, India, Indonesia, Iran, Iraq, Kazakhstan, Kuwait, Libya, Malaysia, Nigeria, Oman, Pakistan, Qatar, Russia, Saudi Arabia, South Africa, Sri Lanka, Chinese Taipei, Thailand, Trinidad and Tobago, Turkmenistan, Ukraine, United Arab Emirates, Uzbekistan, Venezuela, Viet Nam.

Fossil fuel subsidies compared with emissions from fossil fuel combustion

Figure 4.3: Fossil fuel subsidies and CO_2 emissions from fossil fuel combustion for selected countries (2008-2015)



Dots along country lines represent different years from 2008 to 2015. UE27-OECD emissions and subsidies represent the sum of the 21 UE27-OECD countries, as listed in note 24.
Source: Authors' own elaboration of subsidies data from OECD Stats (2019) and emission data from IEA (2020)

Figure 4.3 compares the amount of fossil fuel subsidies in selected countries with their respective emissions from fossil fuel combustion. The graph shows that some of the countries with higher subsidy levels (Iran, Saudi Arabia, Argentina) emit at relatively lower levels than the top emitters (China, the US, OECD-Europe). Thus, removing their subsidies may have a diminished effect at the global level on emissions reduction. China is an exception, since it is both a large subsidizer and a large emitter. India and Russia are also interesting, since their subsidy levels are similar to those of Iran and Saudi Arabia in certain years, but with the difference that India and Russia emit more.

Effects of fossil fuel subsidies removal on reducing emissions in different regions.

Indeed, removing fossil fuel subsidies would have different effects on reducing emissions depending on the region taken in consideration. Subsidies removal results in higher emission reduction in high-subsidizing, high-income, oil and gas exporting regions (Middle East & North Africa; Latin America;

Russia & former Soviet Union countries). In other regions, phasing out fossil fuel subsidies would not be enough to reach the Nationally Determined Contributions (NDCs) (Jewell et al., 2018[25]).

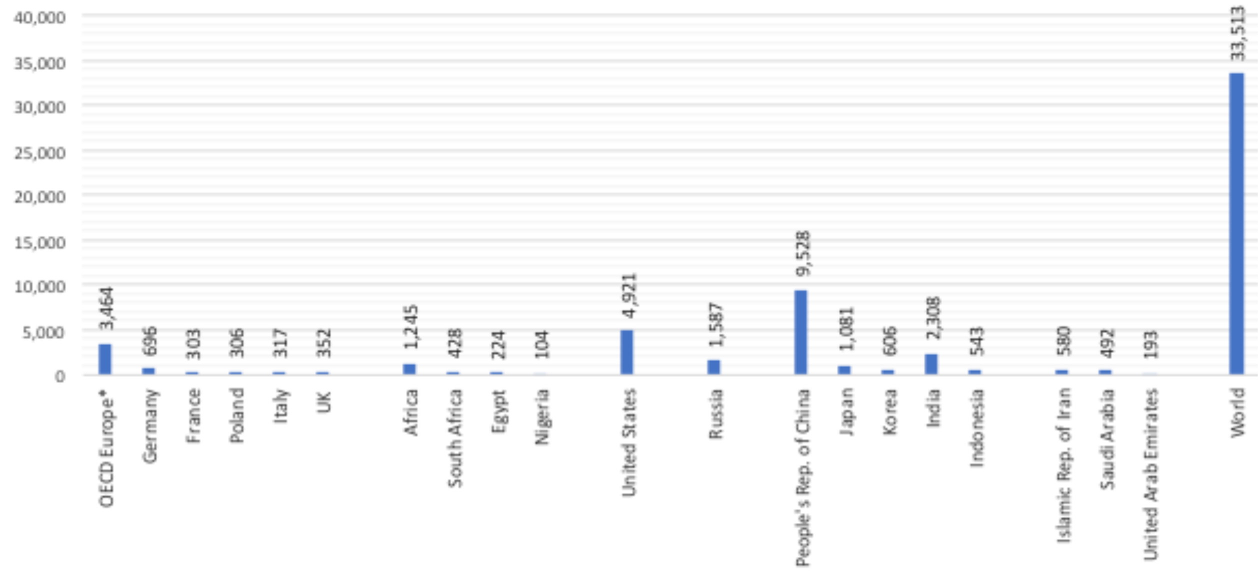
Low oil prices (as in 2015) provide "a unique political opportunity to remove subsidies precisely where it would have the largest effect on emissions and affect a comparatively small number of people living below $3.10 per day", because "low oil prices pressure energy-exporting states to reduce spending as government revenues shrink" (Jewell et al. 2018:232).

Comparison of emissions and emissions per capita across countries

Figures 4.4, 4.5 and 4.6 provide a comparison between absolute emissions from fuel combustion of selected countries, their global emissions share and their emissions per capita.

Oil-exporting and high-subsidizer countries in the Middle East reach considerably high emissions per capita levels in comparison with larger emitters pictured in Figure 4.3, such as the U.S. and China.

4.4: CO2 emissions from fuel combustion for selected countries, 2018 (million tCO_2)

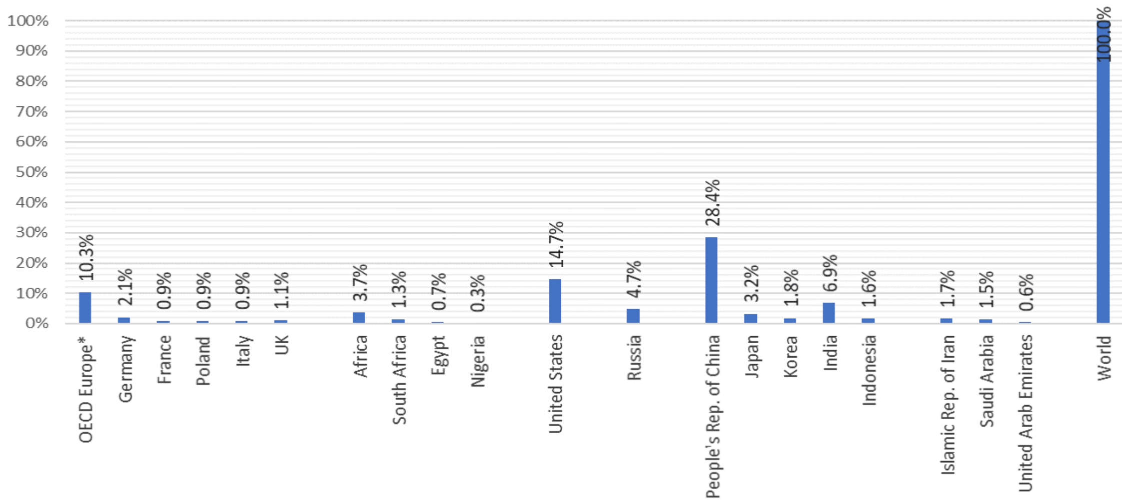


*OECD Europe includes: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

Source: Authors' own elaboration of IEA (2020) data.

[25] Jewell et al. (2018) considered in their paper the IEA and OECD definition of fossil fuel subsidies as "government support of the consumption or production of oil, gas or coal that lowers their prices below normal market prices" (p. 229). They compiled subsidy data from these organizations plus data from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The authors "used five Integrated Assessment Models (IAMs) to evaluate the global and regional effects of removing fossil fuel subsidies on emissions, the energy mix and energy demand under both low and high oil prices" (Jewell et al., 2018: 229). The period evaluated by the study was from 2020 to 2050. The authors also found that "removing fossil fuel subsidies would lower global energy demand. The decrease in energy demand is caused by increasing energy prices and ranges between 5 EJ and 26 EJ per year or 1%–4% in 2030. Under high oil prices, the decrease in demand is larger, reaching up to 30 EJ per year or 7% in 2030" (:232). Regarding the emissions reduction, the paper states that "subsidy removal would lead to a small decrease in global CO2 emissions: 0.5-2 gigatons of carbon dioxide (Gt CO2) or 1%-4% by 2030 under both low and high oil prices" (:231).

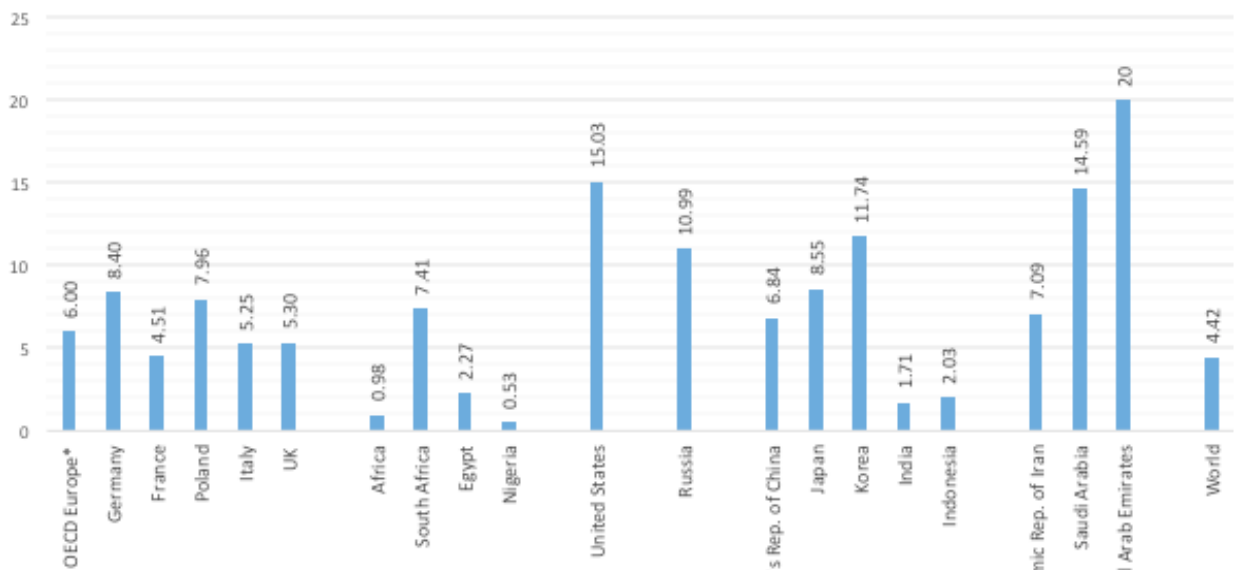
4.5: Global share of CO_2 emissions from fuel combustion for selected countries, 2018 (%)



*OECD Europe includes: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

Source: Authors' own elaboration of IEA (2020) data.

Figure 4.6: Per capita CO_2 emissions for selected countries in 2018 (t CO_2/capita)



*OECD Europe includes: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom

Source: Authors' own elaboration of IEA (2020) data.

4.3 Global fossil fuel subsidies phase-out and emissions reduction

From a global perspective, removing fossil fuel subsidies alone would lead to a smaller decrease in global CO_2 emissions compared to the sum of NDCs. More specifically, subsidy removal would lead to a decrease in global CO_2 emissions of 0.5–2 Gt CO_2 by 2030, under both low and high oil prices. The NDCs from the Paris Agreement add up to a decrease of 4–8 Gt CO_2 from fossil fuels and industry (Jewell et al., 2018).

This result must be contextualized in the study on the effects of subsidy removal only. To reach more ambitious emission results, subsidy removal would need to be accompanied by other policies.

Removing fossil fuel subsidies supports higher carbon price signals. However, by itself, it is not sufficient to decrease GHG emissions as required by the Paris Agreement. Internalizing the cost of fossil fuels externalities in their price, as mentioned in Part One of this document, is important to reduce the carbon intensity of the economy.

In addition, subsidy removal could disproportionately harm the poor in some countries. In this sense, subsidy removal in low-income regions would lead to smaller emission reductions and probably affect more people living below the poverty line. To avoid or reduce the impact of high oil prices on poor households, specific policies with this aim are necessary (Jewell et al., 2018). Parry (2018) also highlights that the rise of fossil fuel prices should be accompanied by measures to compensate low-income households for the resulting higher energy prices and to support workers who might lose their jobs in energy-intensive industries.

Conversely, removing fossil fuel subsidies result in higher revenues that, together with the revenues resulting from carbon pricing, can enhance investment and access to sustainable energy. Both fossil fuel subsidies removal and carbon pricing contribute to the same objective of encouraging the use of less polluting forms of energy.

PART FIVE – A proposal: Global Carbon Pricing and the Fair Transition Fund

Part five contains proposals concerning the contributions to a Global Fair Transition Fund and the distribution of the Fund resources to support affordable access and investment in clean energy in developing countries, mitigation and adaptation policies as specified in SDG 7.

Main proposals are the following:

- Part of the revenues from global carbon pricing could feed a global and inclusive Fair Transition Fund that would be expected to respond to redistribution policies towards developing countries. The Fund resources should be used to finance an inclusive transition, to increase sustainable investment and support policies closely related to the achievement of SDG 7, e.g. through the promotion of universal access to modern energy, including energy for clean cooking, the increase of the share of renewable energy in the energy mix and the improvement in energy efficiency.

- Both the contributions to the Fund and the distribution of its resources would depend on equity, efficiency and sustainability criteria. They should promote carbon neutrality and consider the socio-economic development of countries and their improvements in energy efficiency.

- To benefit from existing structures and expertise, the fund could be part of the Financial Mechanism of the UNFCCC, for example integrating the Green Climate Fund. Results monitoring could also benefit from the expertise of IRENA.

5.1 Carbon pricing revenues feeding a *Fair Transition Fund (FTF)*

A share of the revenues from carbon pricing would remain at the country level, while a flexible share could be directed to the Fair Transition Fund (FTF). This share would be calculated according to specific countries' characteristics and parameters.

The contributions to the Fund would depend on the domestic product of a given country, on the results of its efforts towards decarbonization and would also consider its historical contributions to global climate-change emissions.

The rationale behind the proposal is that the share of carbon pricing revenue to be periodically assigned to the Fund could be proportional to:

- the countries' GDP (addressing the financial gap in developing countries);
- countries' progress in carbon intensity of GDP, thus rewarding countries that are making efforts on the path toward decarbonization (as shown in Figures 3.5, 3.6 and 3.7 in Part Three);

- <u>countries' historical contribution to the overall stock of CO_2</u>[26] in the atmosphere from pre-industrial times**.**

For each country at period "t", the amount of revenues to be given to the Fair Transition Fund (FTF) could be calculated by using the following **EQUATION 1**:

$$\boldsymbol{FTF_{country_i} = RCP_i \cdot \{\alpha + \beta \cdot GDP_i - \gamma \cdot CI_i + \mu \cdot CO_2HC_i\}} \qquad \textbf{(Equation 1)}$$

where:

$\boldsymbol{RCP_i}$	is the Revenue from Carbon Pricing of Country i
$\boldsymbol{CI_i}$	is the carbon Intensity of GDP of Country i
$\boldsymbol{CO_2HC_i}$	is the historical carbon responsibility of Country i
$\boldsymbol{\alpha < 1}$	is a fixed amount of carbon pricing revenues of Country i to be devoted to the Fund
$\boldsymbol{\beta}$	is the contribution proportional to Country I GDP
$\boldsymbol{-\gamma}$	is the reduction of the contribution due to progress in decreasing carbon intensity of GPD of Country i
$\boldsymbol{\mu}$	is the contribution proportional to Country i historical carbon responsibility

Detailing Equation 1:

$$C.FTF_{\ country_i} = RCP_i \cdot \left\{ \alpha + \beta \cdot \frac{GDP_i}{GDP_{wld}} - \gamma \cdot \left[\frac{(CO_2\ /\ GDP)_{i,\ t-1} - (CO_2\ /\ GDP)_{i,\ t}}{(CO_2\ /\ GDP)_{i,\ t-1}} \right] + \mu \left(\frac{\sum CO_2\ emissions_i}{\sum CO_2\ emissions_{wld}} \right)_{t-t_o} \right\}$$

where:

- $C.FTF_{\ country_i}$	"*Contribution to the Fair Transition Fund"* is the amount of revenues to be assigned to the Fund by country "i";
- RCP_i	"*Revenues from Carbon Pricing"* is the amount of revenues levied from total Carbon Pricing in country "i";
- GDP_i	is the GDP of Country "i";
- GDP_{wld}	is the World GDP;
- $(CO_2\ /\ GDP)_{i,\ t-1}$	is the carbon intensity of GDP of Country "i" at previous period (t-1);
- $(CO_2\ /\ GDP)_{i,\ t}$	is the carbon intensity of GDP of Country "i" at current period (t);
- $\sum CO_2\ emissions_i$	is the country "i" contribution to CO_2 emissions in the atmosphere in a certain period of time t-t_0;
- $\sum CO_2\ emissions_{wld}$	is the total quantity of CO_2 released in atmosphere by all countries in the same period t-t_0;

[26] Similarly, the historical contribution of emissions of all Greenhouse Gases (GHG) could be considered rather than just carbon dioxide (CO_2).

- α, β, γ and μ are factors to balance each of the addenda ("$C.FTF_{\,country_i}$" is $\leq$ "RCP_i" → the overall factor in brackets $[\cdots]$ are ≤ 1; in particular: $\alpha < 1$).

Hence, the total amount for the Fund is simply given by:

$$C.FTF_{\,total} = \sum_i C.FTF_{\,country_i}$$

Countries that have lower emissions intensity of GDP in the current period with respect to the previous one will lower the quota to deliver to the Fund by a factor of $\boldsymbol{\gamma} \cdot \frac{(CO_2\,/\,GDP)_{i,\ t-1} - (CO_2\,/\,GDP)_{i,\ t}}{(CO_2\,/\,GDP)_{i,\ t-1}}$, thus obtaining a reward for their efforts.

Parameters α, β, γ and μ are set in such a way that the share of revenues going to the fund is below the total revenue from carbon pricing in the country: accordingly, while feeding the Fund, a share of the total revenues shall remain inside the Country.

Some developing countries would be exempt from transfer to the Fund since, given their characteristics, they would be eligible to receive a higher amount than the one they would transfer to the Fund.

5.2 Distribution of the Fair Transition Fund's resources

The distribution of the *Fund* to developing countries would depend on their relative population and their socio-economic level, measured in term of Human Development Index, on their status regarding the three outcome target envisaged by SDG 7: the access to affordable, reliable and modern energy services, the share of renewable energy in the energy mix and the improvement in energy efficiency. The final component to compute the distribution of the Fund depends on countries' vulnerability to climate change impacts and their readiness to face them.

The following equation will show in an exemplificative manner how the fund could be distributed among countries in each period "t". The rationale behind it is that the distribution of the resources to a developing country could be:

- directly proportional to country's overall population;
- inversely proportional to the country Human Development Index **-H-**;
- inversely proportional to the country's population having access to electricity and to clean cooking **-EA-**;
- inversely proportional to the renewable share in final energy consumption **-RES-**;
- directly proportional to the energy intensity of GDP **-EI-**;
  *The sum of the three previous addenda could be renamed as **S=[EA+RES+EI]***
- directly proportional to the country vulnerability to climate change **-V-**;

as per the following **EQUATION 2, showing the amount of Fund resources to be delivered to county j**:

$$\boldsymbol{Amount_{country_j} = P_j \cdot FTF \cdot \left\{\alpha^* + \frac{\beta^*}{HDI_j} + \gamma^* \cdot EN\ index_j + \mu^* \cdot V_j\right\}} \qquad \textbf{(Equation 2)}$$

where:

$\boldsymbol{P_j}$ is the proportional factor to the Country j population;

$\boldsymbol{FTF}$ is the total amount of the Fair Transition Fund to be distributed;

$\boldsymbol{\alpha^* < 1}$ is a fixed amount to be assigned to the Country j;

$\boldsymbol{\frac{\beta^*}{HDI_j}}$ is the amount inversely proportional to the Country J Human Development Index;

$\boldsymbol{\gamma^* \cdot EN\ index_j}$ is the amount related to the Country J Energy Poverty (Energy Access, Clean Cooking, Renewable share and Energy intensity of GDP);

$\boldsymbol{\mu^* \cdot V_j}$ is the amount related to the Country J climate vulnerability.

Detailing Equation 2:

$$D.FTF_{\ country_j} = \frac{Pop_j}{\sum_j Pop_j} \cdot C.FTF_{\ total} \cdot$$

$$\cdot \left\{ \begin{array}{c} \alpha^* + \frac{\beta^*}{HDI_j} + \left[\gamma_1^* \cdot \frac{(1 - \%\ EA_j) + (1 - \%\ CC_j)}{2} + \gamma_2^* \cdot (1 - \%\ RES_j) + \gamma_3^* \frac{EN/GDP_j}{EN/GDP_{wld}}\right] + \\ + \mu^* \frac{100}{VRindex_j} \end{array} \right\} + \varepsilon^*$$

where:

- $D.FTF_{\ country_j}$ "*Distribution of the Fair Transition Fund"* is the amount to be given by the Fund to emerging or developing country "j";
- Pop_j is the population in emerging and developing country "j";
- $\sum_j Pop_j$ is the total population of all the "j" emerging and developing countries;
- HDI_j is the latest "*Human Development Index"*[27] value for country "j" **-H-;**

[27] The Human Development Index was developed by the United Nation Development Programme, and encompasses health, education and income indicators. Indicators can be found at the following link: http://hdr.undp.org/en/content/human-development-index-hdi .

- $\% EA_j$ "*Electricity Access"*[28] is the proportion of the population with access to electricity in country "j"[29] **-EA-;**
- $\% CC_j$ "*Clean Cooking"*[26] is the proportion of the population with access to clean cooking in country "j" [30] **-CC-;**
- $\% RES_j$ "*Renewable Energy Share"*[26] is the renewable share in total final energy consumption (SDG 7.2) in country "j"[31] **-RES-;**
- EN / GDP_j Energy Intensity of GDP of country "j";
- EN / GDP_{wld} World Energy Intensity of GDP;
- $VRIndex_j$ "*Vulnerability and Readiness Index"*[32] is a vulnerability / readiness for climate change factor of country "j" [33] -**V-**
- $\alpha^*, \beta_n^*, \gamma^*$ *and* μ^* are factors to reach the fairest distribution of the fund among countries (with $\alpha^* < 1$);
- ε^* is the factor balancing the residuals amounts in order to guarantee that $\sum_j D.FTF_{\ country_j} = C.FTF_{\ total}$.

5.3 Carbon pricing revenues supporting a fair energy transition

Revenues from carbon pricing can be used differently, irrespective of the origin of the revenues – whether they come from a national carbon pricing or from the proposed international climate fund. For example, they can be used to enhance programs, reforms, investment plans, activities that contribute to certain environmental and social objectives.

Carbon pricing revenues supporting the energy transition and climate change adaptation and mitigation:

In order to be entitled to spend the share assigned to them by the fund, countries would have to submit investment plans, projects and reforms that will have to comply with specific criteria. The fund will finance environmentally sustainable economic activities that: provide a substantial contribution to at least one of the environmental objectives; do not cause significant harm to any of the other environmental objectives; comply with robust and science-based technical screening criteria and with minimum social and governance safeguards.

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[28] Among the indicators of SDG 7, there are: (i) Proportion of population with access to electricity (ii); Proportion of population with primary reliance on clean fuels and technology; (iii) Renewable energy share in the total final energy consumption; (iv) Energy intensity measured in terms of primary energy and GDP.

[29] IEA, World Bank database)

[30] Data from World Health Organization

[31] IEA database

[32] The ND-GAIN Country Index uses 45 indicators to annually rank 181 countries according to two key dimensions of adaptation to climate change: vulnerability and readiness. The higher the ranking, the better. The vulnerability component measures countries' vulnerability considering six life-supporting sectors: food, water, health, ecosystem service, human habitat, and infrastructure. The readiness component measures a country's ability to leverage investments and convert them to adaptation actions. The 45 indicators to calculate countries' vulnerability and readiness can be found at the following link: https://gain.nd.edu/our-work/country-index/methodology/indicators/ .

[33] UNFCCC refers to the ND-GAIN index – University of Notre Dame Global Adaptation Index, where values are ranging between 0 and 100, where 100 is the best value and 0 is the worst.

Specifically, the environmental objectives could be: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, protection and restoration of biodiversity and ecosystem.

For these reasons, the ***Fair Transition Fund*** would only finance: activities that in and of themselves contribute substantially to one of the environmental objectives; transitional activities where there are no technologically and economically feasible low-carbon alternatives, but that support the transition to a climate-neutral economy in a manner which is consistent with Paris Agreement's goal, for example by phasing out greenhouse gas emissions; fostering activities that enable other activities to make a substantial contribution to one or more of the objectives and where that activity does not cause a lock-in in assets that compromise long-term environmental goals and has a substantial positive environmental impact on the basis of lifecycle analysis[34].

The *Fair Transition Fund* could be used to cover the still existing gap to ensure universal access to affordable, reliable, and modern energy for all by 2030. The fund revenues could be a precious addition to the public financial support needed, for example, to increase investment and access to electricity and clean cooking and to support off-grid energy solutions and renewable energy infrastructure in general.

In order to bridge the investment gap, revenues could also be oriented to attract private financing by de-risking investments in clean energy, e.g., through tax policies and financial instruments (grants, loans, guarantees) on a project-by-project basis.

By 2030 both developed and developing countries need to invest in low carbon technologies. Revenues from the *Fair Transition Fund* could be spent on carbon pricing-complementary environmental policies; in fact, carbon pricing is just one of the instruments that governments can put in place to undertake a cost-effective transition to a low-carbon world. A broad policy framework is needed, including a coherent, inter-related set of measures (Bowen, 2015; Stern & Stiglitz, 2017), which requires financial support. Investments are necessary to finance low-carbon R&D, to support the deployment of renewable energy, and improvements in energy efficiency. Investment in R&D will be essential to speeding up clean energy deployment in sectors where electrification is not feasible or cost-effective, and where low-carbon technologies innovation is still at early-stage implementation. IRENA (2020) suggests, during the recovery phase (2021-2023), an investment in energy transition technologies of $ 2 trillion per year, increased to $ 4.5 trillion for 2024-2030. Investment in low-carbon technologies will also serve the purpose of ensuring that these technologies are absorbed into power systems. Regarding energy efficiency, expenditure in energy efficiency improvements is necessary to make reduced consumption and rising energy demand compatible. The approach of using global carbon price revenues to support complementary environmental policies is shared, for example, by the EU, whose ETS Directive requires “that

[34] For the considerations on the environmental objectives and on the criteria on the investments to be financed with the Fund, we have taken as an example the European Union Taxonomy for sustainable activities regulation and subsequent acts.

Member States should use at least 50% of auctioning revenues or the equivalent in financial value for climate and energy-related purposes” (EU Commission).

Economic impact of carbon pricing policies on households

To support a just transition, in line with the principle of leaving no one behind, carbon pricing effects on households must be considered.

A variety of factors, often country-specific, influence the distributional outcomes of carbon pricing policies (Ohlendorf et al., 2021). The income level of countries is one among them (Ohlendorf et al., 2021; Dorband et al., 2019).

In lower-income countries, especially for very poor or unequal nations, the distributional impact of market-based policies that affect the price of fossil fuels is more likely progressive than in wealthier countries for all market-based policies that affect the price of fossil fuels, e.g., carbon tax, emission trading systems and excises taxes on fuels (Ohlendorf et al. 2021)[35]. Such results could be explained by "low carbon intensities of the consumption baskets of poor households in lower-income countries, resulting from a higher share of subsistence consumption, a low access to modern energy services, or the lack of affordability of energy" (Ohlendorf et al. 2021: 3).

Focusing on low-and middle- income countries, on average carbon pricing can be expected to display progressive effects in poorer countries while having regressive effects in countries with per capita incomes of above roughly USD 15,000. The domestic distribution of carbon prices largely depends on the relative direct energy consumption patterns of the poor. Countries in which carbon pricing would be progressive exhibit lower than the national average energy expenditure shares among the poorest households. Due to the methodology applied, their results can be considered short-term estimates of the impact of carbon prices on household income (Dorband et al. 2019)[36].

In developed economies, on the other hand, more regressive distributional impacts of carbon pricing policies are observed in the literature (Dorband et al. 2019, Wang et al. 2016). For example, a carbon tax without revenue recycling tends to be regressive, but to a rather weak extent (Wang et al. 2016). It can be explained by the more carbon-intensive consumption patterns of poorer households. Low-income households in developed countries spend a larger share of income on energy goods, such as electricity and gas for cooking and heating (Bowen, 2015).

[35] Ohlendorf et al. (2021) conducted a meta-analysis of 53 empirical studies of carbon pricing distributional impacts in 39 countries, resulting in 183 effects in total (144 effects for high-income countries and 39 effects for low, lower-middle and upper-middle income countries). The authors highlighted the smaller number of studies concerning developing countries in comparison to developed countries as a research limitation, although the overall validity of the findings was confirmed by several robustness checks. The study did not analyse the size of the distributive impact and recommend that country-specific context must guide policy formulation and implementation.

[36] Dorband et al. (2019) investigated the distributional impact of a either a globally uniform carbon price, or a domestic price in combination with border-tax adjustment for emissions that were generated to produce imports. They assumed the coexistence of this carbon price with existing subsidies and tax regimes. The carbon price level considered was of USD 30/tCO2.

In developed economies, lower-income households bear a higher carbon tax burden (Wang et al., 2016: 1127).

Furthermore, carbon pricing policies in the transport sector have a highly increased likelihood of progressive outcomes compared to economy-wide carbon pricing policies. (Ohlendorf et al. (2021). Still, this result is sensitive to specific country characteristics. Indeed, there are ambiguous literature conclusions in this regard which mostly show progressive but also regressive impacts of transport carbon pricing policies in high-income countries.

For example, in developed countries, "when distinguishing between domestic energy (cooking, heating and lighting, etc.) and transport fuels, the carbon tax burdens attributable to domestic energy consumption tend to be regressive, whereas those to the transport fuels are weakly progressive" (Wang et al., 2016: 1127). Some OECD countries "show progressive effects of taxes on transport fuels, whereas others either experience more proportional effects or tend to place the highest-burden on middle expenditure deciles" (Wang et al. 2016: 1127).

As the economic impact of carbon pricing on households depends on the carbon intensity of their consumption, the price increase of different fossil fuels due to a certain level of the carbon price is of significance. In annex B, we describe the price adjustment for the physical unit of several fossil fuels at different carbon price levels, considering the fuel carbon content. For example, to a carbon price level of \$60/tCO2 corresponds an additional 16.18 \$ cent/liter for diesel fuel, 13.92 \$ cent/liter for motor gasoline, 9.0 \$ cent/liter for Liquefied Petroleum Gases and 7.07 \$ cent/liter for Liquefied Natural gas.

The possible progressive impact of carbon pricing in general and on the transport sector contrasts with public perception. The public debate usually focuses on the distributional effect of consumer expenditures. At the same time, it underestimates or ignores the usually progressive impact of revenue recycling schemes that can be associated with carbon pricing policies (Ohlendorf et al., 2021).

Using carbon pricing revenues to mitigate the impact of carbon pricing policies on low-income households and citizens.

Even in countries where carbon pricing can have a progressive effect, it increases consumer prices and causes loss of income for low-income households. The poorest in middle-income economies suffer more significant impacts on income than those in lower-income countries.

It is fundamental to keep the electricity and clean cooking affordable. It could be done, for example, by using the revenues from carbon pricing to provide financial support to low-income households (Ohlendorf et al., 2021; Dorband et al.2019; Stern & Stiglitz et al., 2017; Wang et al. 2016; Bowen, 2015; OECD et al., 2015; Lee, 2011).

The negative distributional effects of carbon pricing can be fully neutralized or even reversed (meaning that poorer households may even benefit from such policies) through lump-sum transfers, lower social security or other labour charges, or a reduction of value-added tax (VAT). Beyond that, expenditures to offset the negative impacts of carbon pricing on low-income households are usually lower than the revenues raised by carbon pricing (OECD et al., 2015: 38).

In the case of a regressive distributional impact of carbon pricing, recycling part of the revenues can make the policy progressive.

Some countries have already integrated their carbon pricing schemes with instruments to protect less wealthy families (Bowen, 2015). Among the various instruments that can be used, targeted cash transfer is considered as a valuable supplementary policy to carbon pricing. In British Columbia, for example, the population was given a credit according to their income category. In 2010, the bottom decile received a credit of $122 while paying $129 for the carbon tax, while the top decile paid $795 for the carbon tax and received a credi of $45 (Lee, 2011: 16-18).

Beyond direct measures that balance the regressive impacts of carbon pricing, it is interesting to note that there are some additional benefits deriving from the reduction of emissions that would benefit the poor in a higher proportion: e.g. reduced particulate and local pollution, reduced traffic congestion and increased energy efficiency (Bowen, 2015:10).

To conclude, countries would contribute and receive from the Fair Transition Fund according to the suggestions made with equations 1 and 2 (see part 5.1).

In any case and as per factor α (a fixed amount of carbon pricing revenues of country i to be devoted to the Fund) in the previous equation 1, it has been provided that some countries contribute to the Fund while keeping a share of the revenues at their disposal, while some developing countries only receive from the fund. Irrespective of the origin of the funds (the Fair Transition Fund or the single country's revenues), a possible use would be to divide them into actions to support the environmental objectives mentioned previously and, if needed, the compensation of carbon pricing's economic impacts on low-income households. Since the effects of carbon pricing vary among countries, each country can decide how best to compensate for the impact and the share of revenues directed to compensation and mitigation. Following this approach allows honouring the principle of Just Transition both at the international and at the subnational level.

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ANNEX A – LIST OF COUNTRIES CONSIDERED IN PART THREE

21 countries EU 27 (OECD Countries of EU 27)

1. Austria
2. Belgium
3. Czech Republic
4. Denmark
5. Estonia
6. Finland
7. France
8. Germany
9. Greece
10. Hungary
11. Ireland
12. Italy
13. Latvia
14. Luxembourg
15. Netherlands
16. Poland
17. Portugal
18. Slovak Republic
19. Slovenia
20. Spain
21. Sweden

Other OECD Countries and partner economies

1. Argentina
2. Australia
3. Brazil
4. Canada
5. Chile
6. China
7. Colombia
8. Iceland
9. India
10. Indonesia
11. Israel
12. Japan
13. Korea
14. Mexico
15. New Zealand
16. Norway
17. Russian Federation
18. South Africa
19. Switzerland
20. Turkey
21. United Kingdom
22. United States.

ANNEX B – CARBON PRICING IN NUMBERS

Linking together stoichiometric ratios of fossil fuel combustions (in terms of the quantity of CO_2 generated per unit of fuel, related to its carbon content) and the targeted carbon pricing level ($/$tCO_2$) to be levied, it is possible to evaluate the incidence of the carbon pricing amount and to obtain:

a. the total amount of the economic resources expected by carbon pricing to feed the Fair Transition Fund devoted to green growth;
b. the level of the price adjustment for the physical unit of the considered fuel, measuring the real impact of carbon pricing (datum a certain level of pricing: i.e., 30 $/$tCO_2$).

The table indicates the price adjustment to reach the carbon pricing level of:

- 30 $/$tCO_2$;
- 60 $/$tCO_2$;
- 90 $/$tCO_2$.

for several and different fuels (including main fossil fuels).

For quick reference, the carbon pricing level of 30, 60, 90 $/$tCO_2$ per commercial unit of fossil fuel in figures means:

Main fossil fuel	***carbon pricing level for commercial unit of fossil fuel***		
	(@30 $ / tCO_2)	***(@60 $ / tCO_2)***	***(@90 $ / tCO_2)***
Anthracite Coal	8.6 $ cent / kg	17.21 $ cent / kg	25.81 $ cent / kg
Residual Fuel Oil	8.93 $ cent / liter	17.86 $ cent / liter	26.79 $ cent / liter
Diesel Fuel	8.09 $ cent / liter	16.18 $ cent / liter	24.27 $ cent / liter
Jet Fuel (kerosene type)	7.73 $ cent / liter	15.45 $ cent / liter	23.18 $ cent / liter
Motor Gasoline	6.96 $ cent / liter	13.92 $ cent / liter	20.87 $ cent / liter
Liquefied Petroleum Gases (LPG)	4.5 $ cent / liter	9.0 $ cent / liter	13.5 $ cent / liter
Liquefied Natural Gas (LNG)	3.53 $ cent / liter	7.07 $ cent / liter	10.6 $ cent / liter
Compressed Natural Gas (CNG)	5.77 $ cent / scm	11.55 $ cent / scm	17.32 $ cent / scm