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THE EFFECTS OF CARBON TAXATION ON CLIMATE CHANGE

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ABSTRACT

The carbon tax is the primary mechanism for reducing the greenhouse gas emissions that cause global warming. Yet in adoption, it is the most contentious and limited. The main objective of this paper is to review existing literature about carbon taxes, their implementation stages and effects on combatting climate change.

The main question to be addressed in this paper is whether or not countries introducing the carbon tax have been successful in reduction of carbon dioxide emissions.

The paper is structured as follows: 1st chapter concerns historical attempts and issues to stop climate change; 2nd chapter addresses the carbon tax, its history of evolution and usage as a mechanism for reducing carbon emissions; 3rd chapter reviews the definition of carbon neutrality and examines the means of achieving it; 4th chapter presents the historical importance of the adoption of the Paris Agreement and shows what it has done and what still needs to be achieved; 5th chapter reveals the EU's way of taxing carbon emissions, and after that the 6th chapter outlines the work and draws conclusions.

La tassa sul carbonio è il meccanismo primario per ridurre le emissioni di gas a effetto serra che causano il riscaldamento globale. Eppure, in fase di adozione, è la più controversa e limitata. Gli obiettivi principali vertono sul rivedere la letteratura esistente sulle tasse sul carbonio, le loro fasi di attuazione e gli effetti sulla lotta ai cambiamenti climatici.

La questione principale da affrontare nel presente documento è se i Paesi che introducono la tassa sul carbonio siano riusciti a ridurre le emissioni di anidride carbonica.

Il documento è strutturato nel modo seguente: il primo capitolo riguarda i tentativi storici e le questioni per fermare il cambiamento climatico; il secondo capitolo concerne la tassa sul

carbonio, la sua storia di evoluzione e di utilizzo come meccanismo per ridurre le emissioni di carbonio; il terzo capitolo esamina la definizione di neutralità del carbonio ed esamina i mezzi per raggiungerla; il quarto capitolo illustra l'importanza storica dell'adozione dell'accordo di Parigi e illustra ciò che ha fatto e ciò che deve ancora essere realizzato; il quinto capitolo rivela il modo in cui l'UE impone le emissioni di carbonio, e dopo di che il sesto capitolo delinea il lavoro e trae conclusioni.

1. SELECTED ISSUES CONCERNING ENVIRONMENTAL PROTECTION

In this century, three key forces are transforming the economy: a demographic shift toward an older population, rapid advances in technology, and climate change (Rudebusch, 2019). The most critical environmental issue facing our nation and the globe is global climate change. There is no longer any doubt that there is global warming. Nor is there any substantial dispute about whether the root cause is human behavior. If we fail to reduce greenhouse gas emissions dramatically over the next ten to twenty years, we face the risk of a disastrous climate.

Surface temperatures were first regularly recorded around the world in the late 1800s (Rudebusch, 2019). According to an ongoing temperature analysis conducted by scientists at NASA's Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by a little more than 1° Celsius (2° Fahrenheit) (see Figure 1) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20°C per decade (The Earth Observatory, n.d.). A consensus opinion among scientists is that global warming is the result of carbon emissions from burning coal, oil, and other fossil fuels, based on comprehensive scientific theory and evidence. Indeed, the Swedish chemist Svante Arrhenius demonstrated as early as 1896 that carbon emissions from human activities could, through a greenhouse effect, cause global warming. The underlying science is simple: some greenhouse gases, such as carbon dioxide and methane, absorb the heat of the sun that is reflected off the surface of the Earth, thus preventing the heat from escaping into space. Such greenhouse gases act like a heat-holding blanket around the world. The blanket gets thicker as more fossil fuels are burned, and the global average temperatures rise. Other empirical measurements have confirmed many related adverse environmental changes such as rising sea levels and ocean acidity, shrinking glaciers and ice sheets, disappearing species, and more extreme storms (USGCRP, 2018, as cited in Rudebusch, 2019).

The global climate crisis calls for industry to innovate for overcoming the challenge of reducing emissions of carbon dioxide and to encourage the production of alternative sources of energy. In order to minimize greenhouse gas emissions, it is important that the world takes effective and decisive action (Reuven S. Avi-Yonah, 2009).

By burning fossil fuels, producing cement, raising cattle, clearing land, and other practices, companies, customers, and governments emit carbon dioxide, methane, nitrous oxide, and other greenhouse gases. In the atmosphere, these pollutants build up and trap heat, warm the globe, raise sea levels, change patterns of rainfall, increase storm intensity, and increase the risk of abrupt climate change. Rising concentrations of carbon dioxide also change the oceans' chemical balance, damaging coral reefs and other marine life. Greenhouse gas emissions thus produce a host of possible economic and environmental challenges, including increased storm damage to infrastructure, risks to human health, decreased agricultural production and degradation of the ecosystem (IPCC, 2014, as cited in Donald Marron, 2015).

The problem facing any climate change mitigation campaign is that emissions come from millions of sources and activities. For this purpose, it would be difficult and needlessly expensive to set pollution limits on individual sources, to mandate specific technologies or to create other direct regulations. Some regulations can reduce emissions, but even the best approaches are under the control of some sources, over the control of others and ignoring third ones. In addition, direct regulation does little to reward innovation beyond regulatory lows (Donald Marron, 2015).

Thus, market-based approaches that put a price on emissions are particularly attractive for combating climate change. Setting such a price would allow the market to do what it does best: encourage consumers and enterprises to reduce emissions at the lowest cost and provide a constant incentive for innovators to develop new ways to reduce carbon emissions (Donald Marron, 2015).

As stated by Reuven and Avi-Yonah (2009), the carbon tax levied on all coal, natural gas and oil produced domestically or imported into the country is an effective and efficient market-based solution to reduce the carbon dioxide emissions. A carbon tax would enable the economy to pay the societal costs of carbon dioxide production and thereby contribute to reducing emissions. However, if the resulting market-based reforms were either too weak or too strong, it would be easier to apply and implement a carbon tax and easier to adapt. A carbon tax will also raise revenue that could be used to finance renewable energy research and development and tax credits to offset the regressive impact of the carbon tax. Since a carbon tax could be introduced and almost immediately become effective, it would be a much easier way to reduce greenhouse gas emissions than a cap-and-trade system, which is another market-based mechanism, but which will not be the focus of this paper.

Scientists have expressed concern about rising atmospheric carbon concentrations and the subsequent global climate change for more than forty years. Public interest has lagged behind scientific evidence, and our political leaders have been even slower to recognize the magnitude of the climate change crisis. In the past several years, however, with the release of "An Inconvenient Truth" and growing evidence of global warming, the political debate over the existence of global climate change has largely ended, replaced only by the more difficult question of what to do about climate change (Parson, 2007, as cited in Reuven S. Avi-Yonah, 2009).

The scientific evidence that global warming is occurring is overwhelming. In 1988, the United Nations Environmental Programme and the World Meteorological Organization formed the Intergovernmental Panel on Climate Change (IPCC) to provide objective scientific analysis on all aspects of climate change. IPCC report, released in November 2007, concluded that "eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of

global surface temperatures (since 1850)" (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009). The IPCC stated that increases in temperature have occurred worldwide, but most notably at higher northern latitudes (Revkin, 2008, as cited in Reuven S. Avi-Yonah, 2009).

Arctic ice melted at unprecedented levels in 2007, allowing the famous Northwest Passage to open for navigation for the first time (Coering, 2007, as cited in Reuven S. Avi-Yonah, 2009). A record 552 billion tons of ice melted from the Greenland ice sheet during the same season. In Greenland, it is difficult to overstate the value of melting. Climatologists expect that the entire Greenland ice sheet would melt if global warming persists unabated, causing many meters of sea level rise and coastal flooding that could imperil most of the eastern United States (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009).

While some skeptics argue that global warming is part of normal climate change (Avery, Singer, 2007, as cited in Reuven S. Avi-Yonah, 2009) few climatologists agree. Over time, the earth has undergone cycles of cooling and warming, but warming has never occurred at the rate that it occurs today. IPCC report, released in November 2007 noted that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic [greenhouse gas] concentrations" (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009).

Anthropogenic greenhouse gases include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Carbon dioxide is the main greenhouse gas by far, responsible for about 75 percent of anthropogenic greenhouse gas emissions between 1970 and 2004 (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009). Annual global emissions of carbon dioxide increased "almost fivefold in the past century," and these emissions "have tripled since 1950" (Speth, 2004, as cited in Reuven S. Avi-Yonah, 2009). The

burning of fossil fuels for electricity, heating, air conditioning, and transportation is the most important contributing factor in increasing carbon dioxide emissions; land-use changes, particularly deforestation, have also played a significant but smaller role (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009).

The fact that greenhouse gas emissions continue to rise at an unprecedented pace compounds the climate change crisis. By the end of the century, many areas of the planet would already be uninhabitable if greenhouse gas emissions were to remain at current levels (Speth, 2008, as cited in Reuven S. Avi-Yonah, 2009). Yet the worldwide rate of emissions of greenhouse gases is not stabilizing; it is accelerating. Between 1970 and 2004, the rate of global greenhouse gas emissions from human activity increased by 70 percent (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009). Emissions of carbon dioxide are expected to rise by 55 percent globally between 2004 and 2030 with the rapid industrialization of China and India and the absence of attempts to control greenhouse gas emissions there and in the rest of the world (Speth, 2006, as cited in Reuven S. Avi-Yonah, 2009).

Reuven and Avi-Yonah (2009) claimed that one of the cruel ironies of the crisis of climate change is that developed countries such as the United States have contributed the most to global warming, but the worst ill effects will be experienced by less developed countries. Part of the problem facing less developed countries is that, even without the adverse consequences of global climate change, they are situated in areas of the world where natural resources, most notably water and food supplies, are limited. Moreover, both because of the limitations of natural resources and economic restrictions, less developed countries would be less capable of adapting to climate change when it occurs.

In order to prevent the worst effects of global warming, major reductions in greenhouse gas emissions must occur over the next ten to twenty years. Climatologists warn that to prevent devastating environmental consequences, we must limit global warming to around 2 ° C or 4 ° F. (Warren, 2006, as cited in Reuven S. Avi-Yonah, 2009). To put these estimates in perspective, over the last 10,000 years, average temperatures have only varied by 1.8 ° F. Average temperatures have only risen by 5 to 9 °F since the end of the last ice age (UCSUSA, as cited in Reuven S. Avi-Yonah, 2009).

Stabilization of carbon dioxide concentrations in the atmosphere at around 450 parts per million (ppm) would be needed to limit global warming to 2 ° C or 4 ° F, and some analyses suggest stabilization at 400 ppm or even lower to avoid going above this temperature threshold (Metz, Vuuren, 2006, as cited in Reuven S. Avi-Yonah, 2009).To put those targets in context, preindustrial carbon concentrations in the atmosphere were 280 ppm; today, carbon concentrations in the atmosphere are approximately 380 ppm, which is higher than the natural range over the last 650,000 years. Carbon concentrations will rise by 2 ppm annually at current rates, implying that carbon concentrations will exceed 450 ppm before the middle of this century without reducing carbon dioxide emissions. Unfortunately, unless we take steps to reduce carbon dioxide emissions, we are likely to reach 450 ppm even sooner, because, as noted above, the rate of carbon dioxide emissions is increasing so rapidly (IPCC Report, 2007, as cited in Reuven S. Avi-Yonah, 2009).

The long lag time for decreasing carbon dioxide concentrations in the atmosphere is perhaps the most sobering aspect of the climate change crisis. For several decades, or even centuries, carbon dioxide has existed in the atmosphere. As a consequence, before the second half of this century, the beneficial results of any decrease in carbon dioxide emissions are unlikely to be seen (Stern, 2007, as cited in Reuven S. Avi-Yonah, 2009). To put it differently, the damage we already have

done cannot be mitigated for nearly half a century; our best hope in the near term is to take sufficient steps to limit further damage and to protect ourselves from the catastrophic effects that could occur (Reuven S. Avi-Yonah, 2009)

Because of the disturbing failure of past attempts to minimize greenhouse gas emissions and avoid further warming, the seriousness of the global warming issue has increased. While public and political awareness to global climate change has reached a point where intervention is now possible, for more than a century, scientists have given warnings about the risks of excess greenhouse gas accumulation. An Irish physicist named John Tyndall began researching the atmospheric effects of carbon dioxide nearly 150 years ago. Around the turn of the twentieth century, Swedish chemist Svante Arrhenius asserted that increasing levels of atmospheric carbon dioxide would lead to higher global temperatures (Bernal, 2005, as cited in Reuven S. Avi-Yonah, 2009).

Other European scientists investigated the potential climatic consequences of burning fossil fuels in the decades that followed, and a number of influential American scientists started similar studies in the 1950s (Oreskes, 2007, as cited in Reuven S. Avi-Yonah, 2009). A 1963 meeting of the Conservation Foundation concluded that increased carbon dioxide emissions would lead to a significant temperature increase (Spash, 2002, as cited in Reuven S. Avi-Yonah, 2009). By 1965, President Lyndon B. Johnson told Congress that humans have "altered the composition of the atmosphere on a global scale through ... a steady increase in carbon dioxide from the burning of fossil fuels" (Oreskes, 2007, as cited in Reuven S. Avi-Yonah, 2009). A year later, the National Academy of Sciences concluded that carbon dioxide increases could lead to "inadvertent weather modification." Warnings continued throughout the 1970s, and in 1979, the National Academy of Sciences published the Charney Report, which concluded "[i]f carbon dioxide continues to

increase, the study group finds no reason to doubt that climate changes will result and no reason to believe that these changes will be negligible" (NAT'L ACAD. OF SC. (1979), as cited in Reuven S. Avi-Yonah, 2009).

By the early 1980s, many scientists claimed that greenhouse gases were threatening to trigger a dangerous pattern of global warming, and these scientists and their supporting research organizations sought to convince government officials to pay attention to the problem (Dessler, Parson, 2006, as cited in Reuven S. Avi-Yonah, 2009). By 1985, "growing scientific evidence" of climate change placed the issue on the political agenda. When the World Commission on Environment and Development (later known as the Brundtland Commission) published *Our Common Future* in 1987, climate change from carbon dioxide emissions was listed first among the four "disturbing" environmental risks associated with our high energy use (Our Common Future, 1987, as cited in Reuven S. Avi-Yonah, 2009). The Commission also noted that "we already know enough to warrant action" on global threats such as climate change and stated that it was "urgent" that countries begin working on international agreements to reduce greenhouse gases (Reuven S. Avi-Yonah, 2009).

The scientific findings of the 1970s and 1980s did not lead the United States to take meaningful steps to address global climate change. In 1978, Congress passed the National Climate Program Act, which ordered the President to create a program to "understand and respond" to possible global climate change and and resulted in the Charney Report, which, if carbon dioxide emissions continued to rise, predicted major climate change. "Congress passed the Global Climate Security Act in 1987, forcing EPA to propose a "coordinated national strategy on global climate change," effectively nothing more than the National Climate Program Act had required a decade earlier (In 2009, Reuven S. Avi-Yonah).

The United States experienced a heat wave and a subsequent drought in 1988, which coincided with a Senate Committee on Energy and Natural Resources hearing on the greenhouse effect (McKibben 1989 as cited in Reuven S. Avi-Yonah, 2009). NASA scientist Dr. James Hansen was the chief expert witness, arguing that, based on his own findings and a thorough analysis of scientific evidence, he was ninety-nine percent certain that human activities were leading to increased global temperatures (Reuven S. Avi-Yonah, 2009).

In 1990, the United Nations adopted the Framework Convention on Climate Change (UNFCCC), which led to the adoption, at the 1992 Earth Summit in Rio de Janeiro, of an international treaty, the precursor to the Kyoto Protocol. The United States made it clear during the UNFCCC negotiations that it was opposed to enforceable reduction goals, because President George H. W. Bush was unwilling to commit to any steps that could jeopardize the economy or lifestyle of the United States. Although the momentum towards mandatory reductions in greenhouse gases has been building, the United States has exercised its power to restrict the reach of the Rio Agreement and to avoid committing itself to any mandatory reductions (Reuven S. Avi-Yonah, 2009).

The 1997 Kyoto Protocol was the first international agreement on greenhouse gas emissions with mandatory limits. Under the Kyoto Protocol, developing countries have agreed to reduce their emissions by an average of at least five percent below 1990 levels by 2012. Once again, however, the United States objected, based on economic interests, to mandatory pollution controls. In its concern about the lack of mandatory emission limits for developed countries, the United States was particularly frank. Although the United States made a symbolic gesture of signing the agreement, it did so only by announcing that once the major developed countries agreed to do something, they would not send the agreement to the US Senate for ratification. Indeed, it would have been pointless to submit the agreement for ratification at the time, because the Senate had

already declared in a resolution 95-0 that it was the "sense of the Senate" that no agreement should be signed by the United States that did not require developed countries to restrict their own emissions (Reuven S. Avi-Yonah, 2009).

In its opposition to compulsory restrictions on greenhouse gas emissions, the United States did not relent during the Bush Administration. President George W. Bush publicly announced his opposition to the Kyoto Protocol, which led to a fierce international response, as should have been predicted since the protocol was ratified by more than 175 other countries representing near unanimity throughout the world. The United States and Kazakhstan are the only countries that signed but have not ratified the Kyoto Protocol (Reuven S. Avi-Yonah, 2009).

Although the Kyoto Protocol was an important step in the right direction, commentators have noted that it was "but a baby step in reducing world carbon use and output" (Braasch, 2007, as cited in Reuven S. Avi-Yonah, 2009). The international community has held regular meetings since 1997 to reach consensus on additional emission limits and to extend the conditions for reductions beyond 2012. The 2001 meeting of the United Nations Climate Change Convention resulted in the Marrakech Accords, which recognized the need for going beyond the steps taken in the Kyoto Protocol, although it fell far short of mandating the much larger reductions that many scientists say are needed (UNFCCC 2001 as cited in Reuven S. Avi-Yonah, 2009).

The most significant efforts to control greenhouse gas emissions have occurred in the European Union, which has also initiated its own climate policy. The European Union climate policy includes an agreement among its member nations to impose a cap-and-trade system to meet the reductions required by the Kyoto Protocol (European Union Greenhouse Gas Emission Trading Scheme (2005) as cited in Reuven S. Avi-Yonah, 2009). Yet, during the Bush Administration, even as their allies agreed to limit carbon dioxide emissions, the United States continued to insist

that developing nations must commit to greenhouse gas reductions before the United States would take mandatory action. President Bush declared that the United States would look to economic growth to "provide the resources for investment in clean technologies." Some commentators described this position as stating that "growth is the solution and not the problem." The Bush Administration's position aligned with the historical view of the oil and gas industries, a "business as usual approach" that failed to take into account the damages associated with greenhouse gas emissions. In this sense, President Bush's position was not all that different from the 1997 Senate Resolution, which also called for opposing any international agreement that "would result in serious harm to the economy of the United States (McKibben 2007 as cited in Reuven S. Avi-Yonah, 2009).

Even when the United States has passed related legislation, it has often fallen far short of European efforts. For instance, recent legislation in the United States now requires major automakers to meet an increased standard of thirty-five miles per gallon on average by 2020 (Energy Independence and Security Act of 2007 as cited in Reuven S. Avi-Yonah, 2009), whereas Europe already requires an average of forty miles per gallon (Fairley 2008 as cited in Reuven S. Avi-Yonah, 2009). As a result, the most significant efforts in the United States to address climate change have occurred at the state and local level (Engel, Orbach, 2008, as cited in Reuven S. Avi-Yonah, 2009). California has been particularly aggressive in passing state legislation to curb greenhouse gas emissions, and more than twenty other states have also pursued similar efforts (Kelderman, 2007, as cited in Reuven S. Avi-Yonah, 2009). At the local level, more than 500 mayors have signed a pledge to undertake efforts to cut greenhouse gas emissions and to encourage action at the state and federal level. Unfortunately, their pleas for federal legislation have gone unanswered (Reuven S. Avi-Yonah, 2009).

As it is discussed in the paper by Reuven S. Avi-Yonah (2009), there is no silver bullet to tackle global warming, but climatologists agree that the most critical first step is to curtail the growth of carbon dioxide emissions and, as expeditiously as possible. Although regulatory instruments to reduce carbon dioxide emissions are available and their use may be desirable as part of a broad-based approach to climate change mitigation, policymakers and scholars have centered much of the discussion on market-based approaches to reducing carbon dioxide emissions.

The primary driving force behind market-based approaches is the belief that harnessing market forces is critical to developing the operational changes and alternative technologies needed to reduce carbon dioxide emissions. Theoretically, reliance on market-based forces would allow development of the most innovative and cost-effective form of carbon dioxide reduction (Reuven S. Avi-Yonah, 2009).

Some may question whether relying on market forces is wise to answer to a crisis that has been described as an epic market failure, as free market forces have failed to account for the tremendous economic and social costs that will follow global climate change. From an economic standpoint, however, carbon dioxide emissions are the classic externality: emissions occur at no cost to the emitting facility, but at an enormous cost to the society as a whole. Therefore, a critical element of market-based approaches is the creation of a carbon price signal that integrates the cost of the externality and pushes the market to find suitable alternatives (Reuven S. Avi-Yonah, 2009).

Focusing on market-based solutions to environmental problems that arise from the rapid rise in carbon dioxide emissions that have followed industrialization and growth around the world over the last 150 years might be a leap of faith. Yet, precisely because emissions of carbon dioxide are rising globally and across all sectors of the global economy, a market-based solution could be the best way to resolve all sources of emissions of carbon dioxide (Reuven S. Avi-Yonah, 2009).

Market-based constraints, in addition to encouraging cost-effective strategies, allow the considerable cost of reducing carbon dioxide emissions to be more uniformly spread throughout the economy. There will be economic impacts on any carbon mitigation strategy (Stavins, 2008, as cited in Reuven S. Avi-Yonah, 2009), and no solution can eradicate all disproportionate effects, but a market-based strategy is likely to allow cost sharing to be equitable because it affects the economy as a whole. Finally, a market-based approach can be implemented more rapidly than the regulatory approaches, particularly if a carbon tax is utilized (Reuven S. Avi-Yonah, 2009).

2. ENVIRONMENTAL TAXATION AS A TOOL TO REDUCE NEGATIVE EXTERNALITIES

According to Jaeger (2005), economists focus on two common sources of market failure, public goods and externalities, for evaluating environmental problems.

Lighthouses are *public goods*; so is the ozone layer. There are two distinct aspects of public goods: non-excludability and non-rivalrous usage. "Non-rival", means that consumption or use of the goods by one person does not subtract from the amount of the goods or services that others may use. "Non-excludability" means that it is difficult, or prohibitively expensive, to exclude or restrict the use of public goods by individuals. The most popular example is the ability to watch a firework without being paid for it from a yard or balcony. This also illustrates a very famous "free-riding" issue. If the problem of a free-rider cannot be solved, valuable goods and services - those for which people would otherwise be willing to pay - will remain unproduced. Thus, we face a dilemma: let the public good be undersupplied, or pay for it with taxation in a way that will force some people to pay more than they would like.

At first glance, it would seem that excludability for a public good (the ability to control access) would solve the problem, but this is not the case. With public goods we can either accept undersupply or try to pay for the efficient level of the public good in distortionary and potentially unfair ways. Both have drawbacks (Jaeger, 2005).

An *externality* happens when one person's actions affect another person's well-being and the relevant cost or benefit is not reflected in market prices. Externalities may be positive or negative. Using Pigou's terminology, we say that when externality is present, there is a discrepancy between private and social costs. We interpret this to mean that when all voluntary contract agreements have been entered into by market operators, there remain some interactions that need to be internalized but that market forces themselves cannot handle (Dahlman, 1979).

As Dahlman (1979) claims, certain transactions that would be advantageous are not carried out without intervention in the price process. Two conclusions follow: first, that some government intervention is automatically needed because market forces alone are insufficient to eradicate the remaining inefficiencies; second, the conceptually viable alternative to government intervention is that economic agents can be made to take into account the side effects they produce by the effective establishment of suitable markets.

One may then question why market transactors are unable to internalize the costs of their behavior by the emitter of an externality. The sole explanation why these transactions are not carried out by wealth-maximizing economic agents must be that the expense of carrying out the actual transaction is greater than the anticipated profit. The importance of externalities must essentially lie in the fact that they reflect the existence of certain transaction costs. For if there were no transaction costs, then costless bargaining between self-interested economic agents could realize the possible Pareto improvement. Therefore, transaction costs are a prerequisite for maintaining the undesirable effects from externalities, since in the absence of transaction costs, side effects will be internalized and will not adversely affect the allocation of resources. Thus, the conclusion is unambiguous: in the theory of externalities, transaction costs are the root of all evil (Dahlman, 1979).

The Coase Theorem refers to an important point made by Nobel laureate Ronald Coase in a 1960 paper called "The Problem of Social Cost." The most important point made by Coase, which is not particularly controversial, was that from an economic perspective, externalities are reciprocal. The second point is more controversial, which states that under certain assumptions it does not matter who gets the property right related to an external effect, the outcome could still be efficient. The reason for this is that, assuming zero bargaining or transaction costs, the two parties could

bargain. This part of the Coase analysis is interesting theoretically, but it is largely irrelevant to most real-world problems, because transaction costs are usually prohibitively large (Jaeger, 2005). Yet this is where enthusiasts of the free market jump up and scream, “Ah ha! No government needed; private acts such as bargaining can fix environmental issues, and Coase proved it." Well, not so quickly. If there are no transaction costs, then Coase is right, regardless of who is granted the initial property right, an effective outcome will occur. The presumption that autonomous bargaining can take place becomes highly questionable as the number of people involved rises beyond two or three. Although this was understood by Coase, some current enthusiasts do not understand this concept (Jaeger, 2005).

A third main argument relating to the ideas of Coase concerns only certain types of circumstances where transaction costs are very high and direct negotiation cannot happen. Can we say something about which property right (full liability versus no liability) is preferred or which is more effective, in the absence of any kind of government regulation or other policy? (Jaeger, 2005)

As it is obvious from this analysis, government actions are needed to overcome market failure. This would be understood by a society of rational citizens and would easily mandate the government to do what is required (e.g. taxation, regulation etc.). But questions still need to be answered: should anyone be obligated to pay taxes? Will the same sum be paid by all individuals? What about the disadvantaged, or those living in areas with low environmental damage?

To generalize discussion up to this point, we have that climate change is the product of negative externalities because the damage caused by climate change is not expressed in the prices we pay for products such as oil, natural gas, or coal-fired electricity, now and in the future. This "motivates" us to use more of this commodity than we would use if we paid for the damage caused.

As we saw above, Dahlman (1979) claims that transaction costs are the sole source of externalities. To fight those negative externalities we need to put a price on carbon.

Carbon pricing, based on the polluter-pays concept, has the ability to be an effective policy instrument to minimize greenhouse gas emissions in the fight against climate change. The idea is based on the hypothesis that placing a price on emissions creates an incentive to find cheaper, less polluting ways to do business and transition to lower-carbon consumption patterns. Carbon pricing incorporates the greenhouse gas (measured in CO_2 equivalent) polluter pay concept by placing a tax on each ton of pollution emitted into the atmosphere. Carbon pricing allows for flexibility for private sector investors in terms of when and where to invest in low emissions or alternative technology, creating efficiency by providing an incentive to reduce emissions where it is most cost effective. A price on carbon usually takes the form of either a carbon tax or a requirement to purchase a limited number of tradeable permits to pollute, commonly referred to as a cap-and-trade or emissions trading scheme (Carbon Market Watch, 2017).

The carbon tax is a type of consumption tax which can depend on the CO_2 emissions from energy consumption or fossil fuels. The carbon tax is mainly aimed at mitigating carbon emissions. Thus, the carbon tax also promotes energy saving, development of cleaner and cheaper energy sources, and technological transformation, compared to other energy or environmental taxes (Ghazouani, Xia, Jebli, & Shahzad, 2020).

Both a carbon tax and a cap-and-trade system could be imposed either "upstream" or "downstream." An upstream market-based approach would have the greatest ability to ensure that all sources of carbon dioxide emissions are affected, because it focuses on carbon at the point that it enters the economy. Alternatively, either a carbon tax or a cap-and-trade system could be imposed downstream to the facilities that are the major sources of carbon dioxide emissions. A

well-designed downstream approach could also reach all sectors of the economy, enabling costs to be distributed as evenly as the upstream approach (Reuven S. Avi-Yonah, 2009).

Under a downstream approach, the challenge is the number and types of facilities to be controlled and the inherent complexity of achieving all forms of energy usage, especially the use of motor vehicles and electricity, which contribute significantly to emissions of carbon dioxide. The broader range of facilities to be monitored would heighten the administrative complexity; the increased number of facilities would require greater resources for compliance assurance and enforcement. Moreover, considering their substantial contribution to the issue of carbon dioxide emissions, it is not clear how the use of energy by individuals would be tackled. For these purposes, it would be simpler to introduce either a carbon tax or a cap-and-trade scheme under an upstream policy (Reuven S. Avi-Yonah, 2009).

Carbon tax and cap-and-trade differ in one important theoretical dimension, as well as in many important practical ones. Cap-and-trade, because it imposes an overall cap on the level of emissions permitted in the economy, provides certainty as to the environmental benefit that results from its implementation (Benefit Certainty). However, precisely because it imposes a fixed cap without regard to the cost to the economy at large or to individual polluters of attaining that cap, cap-and-trade suffers from a lack of certainty in regard to the cost it imposes (Cost Certainty). A carbon tax, on the other hand, provides Cost Certainty because the precise amount of the tax is set in advance. However, because the effect of imposing a carbon tax on greenhouse gas emissions is not knowable in advance, the carbon tax does not offer Benefit Certainty (Reuven S. Avi-Yonah, 2009)

An upstream (i.e., imposed at the point of extraction or importation) carbon tax arguably is the most straightforward approach to the global climate change problem. A carbon tax would be

imposed on all oil, coal, and natural gas production, as well as all imports. The tax rate would be based on the marginal cost of carbon dioxide emissions (also referred to as the "social cost of carbon") and would be increased annually to reflect the increase in the harmful effects of carbon dioxide emissions. A carbon tax thereby would provide a price signal that captures what is now an externality, namely, the harmful effects of carbon dioxide emissions. Tax revenues would be used to expand tax credits for the development of alternative energy and to address any regressive effects of the carbon tax (Reuven S. Avi-Yonah, 2009).

In environmental economics, the notion that environmental tax revenues could be used to boost economic development or economic productivity was central to the "double dividend" concept. The name comes from the idea that two "dividends" would be created by implementing an environmental tax: first, a reduction in polluting emissions, and second, an increase in GDP and economic efficiency through the use of environmental tax revenues (Ghazouani, Xia, Jebli, & Shahzad, 2020)

Carbon taxes have been successfully implemented in a growing number of countries. Carbon taxes have been implemented in Quebec and British Columbia as part of Canadian efforts to meet the requirements of the Kyoto Protocol. In addition, Denmark, Finland, Italy, the Netherlands, Norway, and Sweden have introduced carbon taxes in combination with energy taxes. The existing carbon taxes are too new to draw meaningful conclusions about their long-term benefits, but many economists believe that a carbon tax would be the most effective method of reducing carbon dioxide emissions (Reuven S. Avi-Yonah, 2009)

Ultimately, a carbon tax is the core strategy for restricting and eventually eliminating the use of fossil fuels whose combustion destabilizes and damages our environment. It is a way for fuel consumers to compensate for the climate change caused by the atmospheric release of carbon

dioxide. If set high enough, the transition to non-carbon fuels and energy conservation becomes a powerful monetary disincentive that motivates switches to renewable energy across the economy, simply by making it more economically rewarding.

The purpose of the carbon tax is to reflect the true cost of carbon combustion. These costs are borne by those who suffer from the consequences, such as homeowners, farmers and, ultimately, the government. Carbon taxes ensure that companies and consumers pay for the external expenses they impose on society. This is a Piguvian tax, since it returns the cost of global warming to their producers (Amadeo, 2020).

A Pigouvian tax is a government cost on any activity that creates socially harmful externalities – that is, activities that create a negative effect on others in a society but not necessarily the person who does that activity. The theory of externality was developed by the British economist Arthur Pigou. He argued that by taxing activities that affect the economy as a whole and subsidizing activities that assist society as a whole, the government should intervene to correct them. Ideally, a Pigouvian tax would cost the manufacturer the same amount of damage it causes to others (Amadeo, 2020).

A carbon tax that is set at the proper level can adequately stimulate innovation in clean technology and the transition from a high to a low-carbon economy. Such a carbon tax should equal to the "social cost of carbon," measuring the total damage from an additional ton of carbon pollution (Auffhammer, 2018, as cited in Rudebusch, 2019). A crucial consideration in calculating this cost is that carbon pollution dissipates very slowly and will remain in the atmosphere for centuries, redirecting heat back to the earth. Consequently, today's carbon pollution will create climate hazards for many generations to come. A second difficulty in calculating the social cost of carbon is the tail risk, namely, the possibility of catastrophic future climate damage (Heal 2017 as cited

in Rudebusch, 2019). A final complication is that the causes and consequences of climate change are global in scope. The resulting intergenerational and international market failure is so problematic that some economists doubt that a carbon tax alone would suffice (Tvinnereim, Mehling, 2018 as cited in Rudebusch, 2019). Instead, a comprehensive set of government policies may be required, including clean energy and carbon-capture research and development incentives, energy efficiency standards, and low-carbon public investment (Gillingham, Stock, 2018, as cited in Rudebusch, 2019).

At present, energy prices do not reflect the cost of greenhouse gas emissions. Generally, those who benefit from the combustion of fossil fuels do not pay for the environmental harm caused by the pollution. Instead, people around the world, including future generations, are accountable for this cost. Businesses and households that create greenhouse gas emissions do not compensate for the losses and harm caused by the pollution by, say, driving vehicles or producing electricity. Consequently, they have no clear motivation to turn to a low-carbon technology that would minimize pollution.

Around the world, increasingly governments are implementing various forms of carbon pricing, but so far most prices languish below USD10 (Carbon Market Watch, 2017). A recent report from the Organization for Economic Cooperation and Development found that the average carbon price across 42 major economies was around USD35 per ton in 2018 (Amadeo, 2020)

The major advantages and disadvantages of carbon tax are as follows:

Advantages of Carbon Tax:

- Simplicity;
- Generation of revenue;
- Cost certainty;
- Sending clear signal to polluter.

Disadvantages of Carbon Tax

- Political resistance;
- Benefit uncertainty;
- Tax exemptions.

(Reuven S. Avi-Yonah, 2009)

In the last year, growing public and investor pressure has moved climate change further up the agenda. As a result, we saw increased attention and efforts to address climate change around the world. More than 70 countries have committed to working toward net zero emissions by 2050 and to enhance their international climate pledges under the Paris Agreement (for more details, see chapter 4). How these government and private sector pledges will be translated into action will be crucial in ensuring we can confine global warming to below two degrees Celsius. An effective carbon price is one tool that can help both countries and companies to successfully decarbonize economies and supply chains. Encouragingly, as more ambitious climate pledges are taken, many of these programs and strategies are factoring in the role and potential for carbon pricing and carbon markets (World Bank, 2020).

While we may understand the economic theory of carbon pricing: make something more expensive and we will use less of it – the ramifications of shifting to a low-carbon economy will likely require a significant restructure of our economies and societies. The low-carbon transition must have public support and be socially just. Carefully planning these policies, including carbon pricing, and proactive communication on the benefits they can bring to our communities, workers and environment, will be critical. Emissions reductions can bring significant health benefits, while revenue generated from a carbon price needs to be focused on long term solutions. These carbon revenues can be used support other development policies to meet critical infrastructure and education. Furthermore, as traditional means of business and production may be disrupted when these climate policies ramp up, a plan to support these communities will also be important (World Bank, 2020).

In their study published in 2020, the authors Ghazouani, Xia, Jebli and Shahzad identify three general categories of carbon tax revenue applications that could potentially boost economic

activity: reductions in other taxes (such as payroll taxes or corporate or personal income taxes), reductions in the deficit in the government budget or financing of valuable public expenditure.

Carbon pricing policies are spreading across national and state lines, with enhanced collaboration between jurisdictions in order to align their carbon markets, according to the most recent World Bank (2020) report. There are now 61 carbon pricing initiatives in place or scheduled for implementation, consisting of 31 ETSs and 30 carbon taxes, covering 12 gigatons of carbon dioxide equivalent ($GtCO_2e$) or about 22 percent of global GHG emissions (see Figure 2). This is an increase compared to 2019, in which 20 percent of global GHG emissions were covered by ETSs and carbon taxes that were implemented or scheduled for implementation.

Governments raised more than USD45 billion from carbon pricing in 2019. There was a slower annual revenue growth in 2019 than in 2018 (USD1 billion compared to USD11 billion). Almost half of the revenues were dedicated to environmental or broader development projects, and more than 40 percent went to the general budget. The remaining portion was spent on tax cuts and direct transfers (I4CE, 2020, as cited in World Bank, 2020).

The World Bank (2020) report indicates that internal carbon pricing is being used by a rising number of businesses to mitigate emissions through their supply chains. Around 1,600 businesses announced in 2019 that they are currently using internal carbon pricing or that they plan to do so within two years (CDP, 2019, as cited in World Bank, 2020).

Successful carbon tax stories such as that of Sweden – which currently has the highest carbon price in the world at USD119/tCO_2 according to the World Bank (2020) report (see Figure 3) – demonstrate that it is indeed possible to make carbon pricing work: While Swedish GDP grew by 78 percent after the Swedish carbon tax was implemented in 1991, GHG emissions decreased by 26 percent (Schiebe, 2019).

The carbon tax was first introduced at a rate equal to SEK 250 (EUR 23) and has risen steadily over the years. In order to allow households and businesses time to adapt, tax reforms have been introduced step by step. Moreover, carbon tax rises have usually been paired with general tax reliefs in other regions to prevent a rise in the overall level of taxes and to ensure that low-income households are not affected negatively by the tax (Schiebe, 2019).

However, while the carbon tax has been instrumental in achieving reductions in GHG emissions, it is clear that a rapidly rising carbon tax is only feasible if real alternatives to fossil fuels are available to households and businesses (Schiebe, 2019).

Schiebe (2019) claims that the 26 percent reduction in pollution is mainly attributed, on the one hand, to the widespread expansion of the production of fossil-free electricity (mainly nuclear power, hydropower and bioenergy) and, on the other hand, to the widespread expansion of the district heating network (mainly powered by household waste and various residues of wood), which has almost fully phased out fossil heating fuels in Sweden.

With that being said, and although Sweden is indeed a positive example for other countries to look at, many problems remain. The primary one in this regard is the transport sector, which accounts for one third of Sweden's overall emissions, which is certainly a bad news, from a climate perspective. With existing tools, emissions in the transport sector are only expected to decrease by 35 percent by 2030 compared to 2010, far from the 70 percent of Swedish climate targets. In fact, according to preliminary statistics, emissions from the transport sector even increased by 0.5 percent in 2018 as a result of increased lorry traffic. (Schiebe, 2019).

However, the difficulties faced in the transport sector underline, once again, the importance of offering real alternatives where decarburization is politically feasible. Sustainable biofuels have

an important role to play in this respect, as they enable existing vehicles to be replaced. In the long term, however, electrification is key (Schiebe, 2019).

The importance of electrifying the transport sector takes us to the last, interlinked point that is the issue of decreasing state revenues as a result of decreasing emissions. In 2018 the Swedish carbon tax alone secured EUR2.43 billion (USD2.65 billion) to the state treasury, which covers roughly half of the budget for the Swedish defense forces. (Schiebe, 2019).

However, until anything moves in the direction of fixing aforementioned issues, not only does the Swedish carbon tax continue to raise significant revenues, but also, above all, to contribute to reducing emissions of GHGs.

Another example of success is British Columbia: The Carbon Tax Center's 2015 report shows that the carbon tax levied by British Columbia in 2008 had a substantial effect on reducing carbon emissions generated by climate change without affecting economic development. The numbers show 12.9 percent decrease in British Columbia's per capita emissions in 2008-2013 compared to 2000-2007 was 3.5 times higher than the decrease of 3.7 percent for the rest of Canada. This suggests that the carbon tax caused emissions in the province to be appreciably less than they would have been, without the carbon tax. Hereby concluding that in order to continue reducing carbon emissions, the region's modest tax of USD30 (Canadian) per metric ton of pollution (equivalent to about USD20.50 per U.S. short ton) would need to continue its upward trajectory (Komanoff & Gordon, 2015).

According to a study conducted by Ghazouani, Xia, Jebli and Shahzad (2020), only a few countries are currently introducing a carbon tax due to its detrimental effects on the competitiveness of local production and the externality of CO_2 mitigation. The study tries to answer questions, such as: does a carbon tax, for instance, lead to a reduction in CO_2 emissions? If so, how significant is the impact of carbon taxation on the environment? The key hypothesis of this study was whether the

countries who implemented carbon tax had less carbon emission as compared to countries who did not implement such policy.

In order to investigate the real impact of the carbon tax on the mitigation of the rate of CO_2 emissions, the authors estimated its effects in the countries of the European Union which have adopted this policy by using the method of more nearest neighbor matching. The paper focuses on the real mitigation properties during the carbon tax implementation period and tries to give additional evidence to decision makers by evaluating the results. This study makes a comparative analysis for carbon tax implementation and non-implementation European economies. The treatment group (tax implementation countries) includes Finland, Latvia, Denmark, Slovenia, Sweden, Ireland, France, and the United Kingdom, while the non-implementation groups consist of other European economies (Ghazouani, Xia, Jebli, & Shahzad, 2020).

Study showed that the mitigation influence of the carbon tax changes from one country to another. On average, the coefficients for the countries adopting the carbon tax are positive, but none of them exceeds the criterion of importance, showing the limited effects of the carbon tax in these countries. The different influences of the carbon tax in diverse states are essentially due to the different carbon tax rates, the scope of the tax exemption, and the different use of carbon tax revenues. The environmental externality requires a uniform tax proportion for many sectors which also explains why the carbon tax in some countries (for example, Finland) works better than other countries, even if the tax rates nominal are generally lower (Ghazouani, Xia, Jebli, & Shahzad, 2020).

The outcomes from the estimation showed that promoting of carbon tax policies can significantly motivate the mitigation of CO_2 emissions in the EU and have a positive impact on the reduction of CO_2 emissions (Ghazouani, Xia, Jebli, & Shahzad, 2020).

3. CARBON TAXATION AS A TOOL TO REACH CARBON NEUTRALITY

Carbon neutrality implies that carbon sinks provide a balance between emitting carbon and extracting carbon from the atmosphere. Removing carbon oxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide greenhouse gas emissions will have to be counterbalanced by carbon sequestration (European Parliament, 2020).

Carbon sink is any system that absorbs more carbon than it emits. Soil, forests and oceans are the primary natural carbon sinks. Natural sinks extract between 9.5 and 11 Gt of CO_2 per year, according to estimates. In 2019, annual global CO_2 emissions amounted 38.0 Gt. To date, no artificial carbon sinks are able to remove carbon from the atmosphere on the necessary scale to fight global warming. The carbon accumulated in natural sinks such as forests is released into the environment by forest fires, changes in land use or logging. This is why it is essential to reduce carbon emissions in order to reach climate neutrality (European Parliament, 2020).

It is possible to achieve carbon neutrality in two ways:

- By balancing emissions of carbon dioxide emissions with carbon offsets (frequently using carbon offsetting);
- By reducing carbon emissions to zero through changing energy sources and industry processes. GHG emissions are reduced by shifting towards the use of renewable energy (e.g. hydro, wind, geothermal and solar power) as well as nuclear power. Carbon projects and emissions trading are often used to reduce carbon emissions.

A carbon credit is a common term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the equivalent quantity of a different greenhouse gas (tCO_2e).

Based on explanation given in the World Bank's (2020) report, carbon crediting is the process of issuing tradable units to actors that are implementing approved emission reduction activities. The carbon crediting mechanisms are categorized, based on how credits are produced and the way the crediting mechanism is administered. There are three categories:

- International crediting mechanisms;
- Independent crediting mechanisms;
- Regional, national and subnational crediting mechanisms.

These emission reductions reflect prevented or sequestered emissions that are additional to business-as-usual operations. This means that emissions are lower as a result of these practices than they would be in a counterfactual scenario without the benefits from the crediting scheme. Credits are created voluntarily and exist outside of the scope of other carbon pricing programs where covered entities have a compliance requirement, making them somewhat different from allowances under a cap-and-trade scheme or performance credits under a baseline-and-credit ETS (where compliance entities are granted credits when they exceed their emission reduction targets). In addition to project-based mechanisms, crediting can also be extended to include policy-wide crediting mechanisms (World Bank, 2020).

One way to use credits issued under carbon crediting mechanisms can be as "offsets". This means that it is possible to use pollution reductions achieved by one entity to offset (i.e. offset) emissions from another entity. Apart from offsetting emissions for carbon tax enforcement or ETS compliance commitments, there is also a voluntary market where carbon credits are used on a voluntary basis to offset individual and corporate emissions. Credits can also be used to measure and reward emission reductions from carbon financing programs. While the majority of carbon credits are used for offsetting purposes, it is necessary to differentiate between the unit which

represents the confirmed reduction of GHG emissions (i.e. credit) and the unit which may or may not be offsetting from its specific use (World Bank, 2020).

The Clean Development Mechanism (CDM) of the Kyoto Protocol originally introduced the carbon compliance market. The Kyoto Protocol signatories agreed on mandatory emission reduction targets allowing CDM-facilitated (partly) carbon offset purchases by higher-income countries from low- and middle-income countries. In 2020, the Kyoto Protocol expired and was replaced by the Paris Agreement. The determinations of the Paris Agreement relating to the position of carbon offsets are still being decided through international negotiations specifying the language of Article 6. The carbon offset compliance markets include international carbon markets established through the Kyoto Protocol and the Paris Agreement, as well as national carbon pricing programs that include carbon offset mechanisms.

Carbon credits can be used for a variety of purposes. They can be defined domestically under a carbon tax or ETS as part of an entity's obligations. Through providing financial incentives (i.e. monetizable carbon credits) to industries not covered by a mandatory carbon pricing initiative, in addition to offering controlled businesses some flexibility for compliance, they could be motivated to minimize their emissions and foster low-carbon innovation. In order to meet corporate social responsibility or voluntary climate targets, credits can also be purchased voluntarily by businesses. Furthermore, to meet their NDC (nationally determined contributions) goals, countries will exchange credits as mitigation effects (World Bank, 2020).

While most credit systems have been developed for domestic enforcement purposes, Article 6 of the Paris Agreement provides additional considerations for countries trading credits internationally.

Article 6 of the Paris Agreement (more on the Paris Agreement in Chapter 4) sets out a mandate for countries to pass mitigation results in order to fulfill their NDCs, either by Article 6.2 or 6.4. When it comes to global crediting, two main problems arise: double counting and the effect on the seller country of sale mitigation results. Firstly, there will have to be arrangements in place to ensure that pollution reductions in the selling country could only be counted against the NDC goal of the buying country. They should also not be counted against achieving the NDC goal of the seller region. Secondly, the selling country must be informed that its mitigation commitment will need to be tightened.

Even if the reductions or removals have taken place beyond the scope of the NDC commitment of a country or are not required to satisfy its current NDC commitment, the capacity of the country to fulfill potential NDC commitments may be expensive. Unlike crediting under the Kyoto Protocol, since all Parties to the Paris Agreement have NDC obligations, there is an opportunity cost of selling credits under Article 6 that Parties will need to assess. If voluntary credit takes place within their jurisdiction, this will also be a relevant concern for a government. It will also be important to recognize the effect this would have on its ability to meet current or potential NDC goals, given that voluntary credit systems obey similar double-count exclusion laws (World Bank, 2020).

A main advantage of carbon crediting is that by financing mitigation in industries and/or jurisdictions where the cost is lower, consumers are given the flexibility to reduce some of their emissions. The lowering of mitigation costs could encourage an increase in the ambition for climate action (IETA, 2019, as cited in World Bank, 2019). As long as the reductions generated from crediting activities are real, crediting can also speed up climate action by enabling reductions to happen faster. While crediting provides flexibility in how entities can reduce their emissions,

their abatement strategies would need to go beyond offsetting. Entities will need other measures to drive down emissions in their own operations (World Bank, 2020).

Projects that produce carbon credits may also generate additional co-benefits beyond the pollution reduction gain. Carbon credit schemes may be expressly designed to encourage or strengthen particular co-benefits, such as health outcomes (e.g. decreased indoor air emissions through the implementation of enhanced cookware), biodiversity, durability, conservation of water and preservation of habitats (World Bank, 2020).

According to World Bank's latest (2020) report, as of the December 31, 2019, there are 14,550 carbon crediting "projects" registered worldwide under the 23 carbon crediting mechanisms. Of these projects, 7,759 have provided carbon credits amounting to some 3.9 billion tCO_2e, equivalent to taking over 842 million passenger cars off the road for one year. As shown in the map (see figure 4), there are 17 regional, national and subnational implemented crediting mechanisms that have issued credits. Five are in development. The majority of implemented mechanisms are operated by jurisdictions in North America and East Asia.

The Kyoto crediting mechanisms (the Clean Development Mechanism and Joint Implementation) have accounted for nearly three-quarters of all credits issued to date, with 70 percent of those originating from projects in industrial gases, renewable energy and pollution emissions. The CDM is the largest issuer, responsible for just over 50 percent of all credits ever issued (World Bank, 2020).

An inspection of historical levels of global credit activity by the World Bank (2020) reveals that credit activities grew steadily until 2012 before collapsing in 2013, but have stabilized since 2015, coinciding with the Paris Agreement being adopted. The spike in activity in 2012 reflects the rush to register CDM projects and issue Kyoto credits before the end of the first implementation cycle

of the Kyoto Protocol in order to escape the numerous restrictions on enabling post-2012 CERs (Certified Emission Reductions - CERs) to join the EU ETS, at that time the largest purchaser of Kyoto credits. As a result of the financial crisis and the over-supply of EU allowances, the general lack of demand for Kyoto credits after 2012 was primarily exacerbated by the lack of demand for EU ETS facilities. In fact, this resulted in a decrease in the price of CERs. The other carbon markets, in turn, have also moved to reduce the amount of Kyoto credits permitted under their scheme. Demand for CERs has not kept pace with their issuance, leading to a market surplus of CERs. As new credit structures begin to come online, the gradually decreasing number of CDM credit issuances in recent years indicates an end to the CDM/JI dominance of the global credit market, especially as the future of these credits under the Paris Agreement remains uncertain.

Let us explore an alternative approach to pricing carbon emissions, which is through emission trading schemes, as carbon offsetting has already been discussed. In the case of emission trading schemes, businesses are required to buy allowances to cover their emissions, the government controls the total supply of allowances, and an emission price is set for trading allowances between firms. To date, trading systems have been primarily limited to power producers and large enterprises, but in contrast to more robust pricing, their CO_2 reduction benefits have been decreased by 20-50 percent across different countries. It also restricts future auctioning allowance revenues (similarly carbon taxes, like other types of taxes, often include exemptions). And while trading schemes provide greater certainty with regard to future emissions, they provide less certainty with regard to emission rates, which could discourage investments in renewable technology. They often require new administrations to track emissions and trading markets and large numbers of participating companies, which could prohibit them from being used in limited or capacity-restricted countries (Parry, 2019).

As Parry (2019) notes in his paper, while nearly 60 carbon tax and trading schemes are in place in different countries at national, sub-national, and regional levels, the average global emission price is only USD2 a ton, a small fraction of what is required. The political challenge of ambitious pricing is highlighted by this. Where carbon pricing is politically limited, it could be reinforced by policymakers with other approaches that do not place a new energy tax burden and thereby avert major rises in energy prices.

Parry (2019) clarifies that a more conservative solution would be to use legislation to regulate items like the energy efficiency of goods or the pollution rates of power generators. In fact, many, but not all, of the behavioral responses resulting from carbon pricing may be imitated by a robust set of regulations: regulations do not induce individuals, for example, to drive less or turn down the air conditioner. Regulations often appear to be inflexible and difficult to coordinate cost-effectively across industries and businesses.

Revenue-neutral "feebates", says Parry (2019), which include a sliding scale of payments for goods or activities with above-average emission intensity and rebates for those with below-average intensity, are a more promising and novel alternative to regulations. For example, if feebates were extended to power generators, producers would pay a tax on the difference between their CO_2 emission rate per kilowatt hour of generation and the industry-wide average emission rate, in proportion to their electricity production times.

Previous experiences with carbon pricing and wider improvements in the area of energy pricing in many countries indicate several methods to boost their acceptability. Pricing can, for instance, be phased in gradually to give time for companies and households to adapt. And an upfront targeted assistance package that requires to use just a small fraction of the income from carbon pricing can

be given to disadvantaged families, enterprises, and communities by, for example, stronger social security networks and worker assistance programs (Parry, 2019).

Especially critical is the open, fair and efficient use of the bulk of carbon pricing revenues. A carbon tax of USD70 a ton in Canada and the United States and a tax of USD35 a ton in China and India will introduce extra bills for the average household of about 2 percent of their consumption in 2030 through their effect on the price of energy and general consumer goods. But if, for example, transfer payments were used to compensate the bottom 40 percent of households for the burden of higher prices, and the remaining revenue (approximately 70 percent) was used to support the country's economy through widespread tax income cuts or rises in productive investment, then the bottom 40 percent of poor households in all four countries would be better off overall, while the average overall burden on higher-income households would be pretty modest, at about 1-2 percent (Parry, 2019)

By contrast, a package of feebates designed to deliver the same economy-wide reduction of emissions as the tax would place a burden on all households, but this burden would usually be less than 1 percent of consumption. In short, strategies for carbon reduction need not place heavy burdens on large classes of households. It can help to lessen public resistance to change by transmitting this message clearly to the public (Parry, 2019).

At the international level, a carbon price floor arrangement among heavily emitting countries could improve and reinforce the Paris Agreement mitigation mechanism. Such an agreement would guarantee a minimum level of effort among participants and provide some reassurance against losses in international competitiveness. Coordination in regard to price floors rather than price levels would encourage countries to surpass the floors, if necessary, to fulfill their Paris Agreement mitigation pledges. And the floors could be built to accommodate carbon taxes and pollution-

trading schemes as well as other approaches including feebates that produce the same emission outcome as would have existed under the floor price (Parry, 2019).

There are some monitoring challenges—for example, countries will need to agree on protocols to account for potential exemptions in carbon-pricing systems and adjustments in preexisting energy taxes that could mitigate or improve carbon pricing's effectiveness. But these technological problems should be manageable (Parry, 2019).

Given their lower per capita income and their smaller contribution to the historical accumulation of greenhouse gases in the atmosphere, it can be concluded that emerging economies have lower minimum price requirements than advanced economies. For example, if advanced and emerging G20 economies were subject to carbon floor prices of USD70 and USD35 per tonne of CO_2, respectively, in 2030, the mitigation initiative would be well over twice as much as the reductions implied by meeting current mitigation commitments. However, additional steps equal to a global average carbon price of USD75 a ton will still be needed to reduce emissions to a level consistent with a 2 ^{o}C target (Parry, 2019).

Just three nations, China, India, and the United States, account for around 80 percent of G20 countries' low-cost mitigation opportunities, so a pricing agreement alone between these three nations will be a major step forward and could catalyze action elsewhere. There are, however, some reasons for optimism. For example, given the longer-term budget outlook, fiscal reduction steps are likely to be required at some point in the United States, and carbon taxation may be easier to stomach than raising business and household taxes or reducing entitlements (Parry, 2019).

There is a lot of discussion about the prospect of a Green New Deal to quickly decarbonize economies more immediately, and carbon pricing may play a key role in that. Carbon pricing is in the interests of China and India when the benefits of decreased mortality from air pollution are

considered: a carbon tax of USD35 a ton in 2030 will save an estimated 300,000 premature deaths a year in China and an estimated 170,000 in India. And it is in the interests of all countries to see successful international-level mitigation to stabilize the global climate system, avoid domestic climate-related disruption, and protect the environment for future generations (Parry, 2019).

Restrictions arising from the COVID-19 pandemic have culminated in a global economic downturn, with wider consequences for climate action, According to the World Bank (2020) study. The economic crisis induced by COVID-19 has led to significant changes in the consumption of energy and consumer behavior, challenging several countries' economic foundations. As societies begin to bounce back and talks shift to packages for recovery and stimulus, countries should explore how actions can be planned to better help the transition to a low-carbon economy. Measures for kick-starting economies could be designed to create jobs and infrastructure that would help the mid-century transition to net zero emissions.

In line with the decreased economic activity resulting from COVID-19 restrictions, prices have decreased in some existing ETSs. In addition, some jurisdictions have postponed steps to improve their carbon pricing instruments and, owing to the limitations, have extended enforcement deadlines. Key meetings have been delayed, most notably COP 26 (Conference of the Parties), as well as international aviation and maritime meetings, delaying decisions on regulations for international transactions and markets. In addition, COVID-19 has contributed to increased concern about the market for foreign airline credits, challenging the effect of COVID-19 on their offsetting commitments under the Carbon Offset and Reduction Scheme for International Aviation (CORSIA) (World Bank, 2020).

Despite the social and economic upheaval, claims the World Bank (2020) report, many jurisdictions and private organizations are accelerating their efforts on climate action. COP 25

stressed the importance and need for ambition to increase as parties work to upgrade their nationally defined contributions (NDCs). The Chilean COP Presidency also announced that 120 parties to the United Nations Framework Convention on Climate Change (UNFCCC) are working as part of the Climate Ambition Alliance to reach net zero CO_2 emissions by 2050. As of 1 April 2020, on the basis of this commitment, Denmark, France, New Zealand, Sweden and the United Kingdom have introduced into legislation a net zero CO_2 emissions target, while Suriname and Bhutan are already carbon negative. Moreover, 15 subnational regions, 398 towns, 786 companies and 16 investors have also stated that they are working towards achieving net zero emissions goals (UNFCCC, 2019, as cited in World Bank, 2020).

The carbon pricing story was one of growth in 2019, with jurisdictions widening their carbon pricing coverage to improve their ambition for the environment. In order to meet reduction targets, more jurisdictions have begun to explore complementary carbon pricing policies outside the coverage of their current carbon pricing schemes. For example, for sectors not included in the European Union Emissions Trading Scheme (EU ETS), carbon pricing is expected in Europe, Germany, Austria and Luxembourg, and the EU's Green Deal, with its pledge to achieving carbon neutrality by 2050, has reinforced the case for broader carbon pricing coverage. Secondly, the variety of current proposals for carbon pricing is rising. In order to control more businesses, more industries and gases are protected by a carbon price and limits are being reduced, including in Chile, Iceland, New Zealand and Switzerland. Many jurisdictions are growing the use of credit systems and results-based climate finance to achieve net zero (RBCF). Finally, countries could be motivated to proactively introduce their own carbon pricing policies, with carbon border changes back on the table in Europe (World Bank, 2020).

The increase in the number of carbon pricing policies is largely taking place in the Americas, as predicted in the World Bank's previous year's (2019) research. Mostly guided by the federal carbon pricing policy of Canada, 2019 saw a flurry of subnational programs arise across provinces and territories, complemented by backstop strategies for federal carbon pricing. This year (2020) also marked the launch of the pilot phase of the national carbon market in Mexico, representing Latin America's first emissions trading scheme (ETS) (World Bank, 2020).

Carbon pricing policies, with increased collaboration between jurisdictions to align their carbon markets, are spreading across national and state lines, according to the World Bank (2020) report. On 1 January 2020, the Swiss ETS and the EU ETS became joined in Europe, enabling protected entities in the Swiss ETS to use EU ETS allowances for compliance, and vice versa. The UK is considering adopting its own ETS and connecting it to the EU ETS, following its withdrawal from the EU and, eventually, the EU ETS (Government of the United Kingdom, 2020, as cited in World Bank 2020). Similarly, the Regional Greenhouse Gas Initiative (RGGI) has grown to include New Jersey and Virginia in the US, a collection of Northeastern states with a regional carbon market for the power sector. Pennsylvania is interested in entering RGGI, and its participation will greatly increase the size of the carbon market, bringing into the initiative a large fossil fuel state. Additionally, in the United States, a consortium of ten Northeastern states are pushing forward with a cap-and invest program for their transport sector.

The last few years have seen an uptick in interest in crediting, with forestry at the forefront. Over the past five years, 42 percent of the crediting demand has come from forestry. This may be partly motivated by the considerable potential for these ventures to cost-effectively reduce pollution and their ability to produce additional co-benefits, in line with a wider interest in nature-based

solutions. Traditional crediting practices in the sectors of industrial gases, renewables and fugitive emissions, however, still account for a substantial share of the market (World Bank, 2020).

Crediting activities are beginning to move beyond projects created by the mechanisms of Kyoto. The Clean Development Mechanism (CDM) has always dominated crediting, but credit activity stabilized following the collapse of the CDM market price in 2012. In the voluntary market, companies remain active, with credits from independent crediting mechanisms accounting for nearly two-thirds of all credits released in 2019. Governments are also building domestic crediting mechanisms. These projects not only produce local benefits, but also provide companies with some flexibility to comply with domestic carbon pricing regulations. International mitigation results are the source of only two nationally controlled mechanisms (in Japan and the Republic of Korea). Continuing discussions around the CORSIA baseline, an international aviation offset mechanism mandating international airlines to surrender qualifying credits to minimize emissions, could also increase credit demand (World Bank, 2020).

In order to ensure environmental integrity, greater accountability and consensus on rigorous standards for crediting mechanisms are required. The increase in the number of regional, national, sub-national and independent credit mechanisms also raises the challenge of ensuring consistency across the different mechanisms and of mitigating a lot of CO_2e for each credit produced. The cornerstone to the credibility of systems is the environmental integrity of carbon reductions and the prevention of double counting (World Bank, 2020).

4. THE PARIS AGREEMENT AND CARBON TAXATION

The creation of the Intergovernmental Panel on Climate Change in 1988 by the United Nations Environment Program and the World Meteorological Organization was the first official action to tackle the climate change issue. In 1990, the IPCC published its First Assessment Report, which presented evidence of climate change. At the 1992 Rio Earth Summit, when 155 nations signed the Framework Convention on Climate Change, this report was used as a basis for negotiating an international agreement to regulate GHG emissions (FCCC). The agreement called for countries to take voluntary measures to reduce emissions to the levels prevailing in 1990 and no binding provisions were made (Cuervo & Gandhi, 1998).

In 1995, the Conference of the Parties (COP) was established as the FCCC's ultimate authority. The first session of this Conference (COP-1) took place in 1995, where the core question of the adequacy of the promises made in Rio was debated in order to counter global warming. Very few countries have been found to have decreased or even stabilized pollution to 1990 levels. At the conference, it became apparent that a different type of commitment was called for. The IPCC also published its Second Assessment Report (SAR) in 1995, which concluded that if emissions continued to increase unabated, the average surface temperature of the planet could rise between 1 and 3.5 degrees Celsius by 2100 (which for the last 10,000 years would be higher than during any century), with effects ranging from increased drought to increased flooding (Cuervo & Gandhi, 1998).

The COP agreed at its second meeting (COP-2) in 1996 that legally binding GHG reduction goals were urgently called for. The COP, at its third meeting in Kyoto in December 1997, accomplished precisely such objectives (Cuervo & Gandhi, 1998).

Although six distinct GHGs-carbon dioxide, methane, nitrous oxide and three halocarbons used as replacements for ozone-damaging CFCs-causing global warming were recognized by the Kyoto

Protocol, carbon dioxide was considered the largest single greenhouse effect contributor with a longer atmospheric lifespan. Therefore, analysis of alternative policy measures in the literature focused on reducing C02 emissions as the most important single step in mitigating the effects of global warming (Cuervo & Gandhi, 1998). Despite its benefits, the Kyoto Protocol was an agreement always fraught with disagreement.

The Paris Agreement is the culmination of the international community's years of attempts to bring about a universal multilateral climate change agreement. Brief evolution of the Global Climate Effort looks like this:

- *Copenhagen – 2009*

  - The Copenhagen Accord is a non-binding document negotiated by the leaders of some 30 countries in the final hours of the conference;
  - The Accord was not adopted as a UN decision but has been endorsed by over 140 UNFCCC Parties. All key elements were subsequently formalized in Cancún.

- *Cancún – 2010*

  - Acknowledged for the first time in a formal UN decision that global warming must be kept below 2°C compared to pre-industrial temperatures;
  - Agreed on stronger rules for the monitoring, reporting and verification (MRV) of emissions and of climate finance;
  - Formalized developed countries' commitment to provide nearly USD30 billion in 'fast start finance' over the years 2010-2012 to help developing countries;
  - Established the Green Climate Fund and new structures and institutions to enhance support to developing countries – e.g. on technology transfer, adaptation and tropical deforestation (REDD+).

- *Durban – 2011*

- Set up the Durban Platform for Enhanced Action to negotiate a new global legal framework covering all countries by 2015;
- Made the Cancún Agreements operational and built on them – e.g. a new market-based mechanism to enhance cost-effective emissions cuts, a process to consider climate issues related to agriculture.

- *Doha – 2012*

- Finalized details of the 2nd period of the Kyoto Protocol;
- Agreed a work plan for negotiations on the new global agreement;
- Operationalized the technology mechanism established in Cancún and launched a work programme on the market mechanism established in Durban.

- *Warsaw – 2013*

- Agreed a time plan for countries to table their intended contributions for the new global climate agreement and on ways to accelerate efforts before 2020;
- Set up a mechanism to address losses and damage caused by climate change in vulnerable developing countries;
- Enhanced the implementation of measures already agreed – e.g. on climate finance, REDD+, and transparency of reporting on emissions.

- *Lima – 2014*

- Required all countries to describe their intended contributions for the 2015 agreement clearly, transparently and understandably;
- Agreed on draft elements for the agreement and on accelerating pre-2020 action.

Source: (The road to Paris, n.d.)

Building on 187 countries' national climate plans, the Paris Agreement represents the remarkable momentum of cities, industries, civil society organizations and others that have complemented the global will to take action that has evolved over the years since the first international climate change conference in 1992 (David Waskow, 2015).

The Paris Agreement is the world's first universal, legally binding international climate change treaty. At COP 21 in Paris, it was adopted by 196 parties on 12 December 2015 and came into force on 4 November 2016. The Paris Agreement provides the overall framework for international cooperation to fight climate change and specifically to hold the increase in the global average temperature to well below 2 °C with best efforts to limit warming to 1.5 °C and to reach net zero emissions by 2050. Countries aim to hit global peaks in greenhouse gas emissions as soon as possible to create a climate-neutral planet by mid-century, in order to achieve this long-term temperature target (The Paris Agreement, n.d.). They will do that taking wealth, sustainable development and poverty into account.

The Paris Agreement is a milestone in the process of multilateral climate change since, for the first time, a binding agreement brings all nations together to make ambitious attempts to combat and respond to the consequences of climate change.

Governments agreed:

- A long-term objective of maintaining the global average temperature rise to just below 2°C above pre-industrial levels;
- To try to limit the rise to 1.5°C, as this will greatly reduce the risks and consequences of climate change;
- On the need for global emissions to peak as soon as possible**,** recognizing that this will take longer for developing countries;

- To pursue rapid reductions thereafter, in line with the best available science, in order to achieve a balance in the second half of the century between emissions and removals;
- Come together every 5 years to review joint progress towards long-term objectives and to advise the Parties to update and enhance their nationally determined contributions;
- Report to each other and the public about how climate action is being implemented;
- Track progress on their obligations under the Agreement through a comprehensive framework of transparency and accountability;
- Strengthen societies' ability to deal with the impacts of climate change;
- Provide developing countries with continued and enhanced international support for adaptation;
- The EU and other developed countries will continue to promote climate action in developing countries to minimize emissions and create resilience to the impacts of climate change.
- Other countries are encouraged to provide or continue to provide such support voluntarily;
- Developed countries intend to follow their current joint goal of mobilizing USD 100 billion annually by 2020 and to extend it until 2025. After this time, a new and higher target will be set for.

Source: (Paris Agreement, n.d.)

Countries have submitted detailed national climate action plans (nationally determined contributions, NDCs) as a response to the goals of the agreement. These are not yet sufficient to achieve the accepted temperature targets, but the agreement traces the way for further action.

Many countries have actually submitted their new plans, known as COP21, before the climate change conference, but those promises are not adequate to hold warming below the 2°C target. But

the expectation of the participants is that countries can strive for more ambitious targets over time and ratchet up their commitments (John D. Sutter, 2015).

Exactly how much each country would reduce its greenhouse gas emissions is not required by the agreement. Rather, it creates a bottom-up structure in which each nation sets its own target and then must specify how it aims to achieve that goal. Those commitments are voluntary, but must be increased over time, and each country will have to send new proposals every five years from 2018 onwards (John D. Sutter, 2015). A common commitment among advanced economies is to reduce emissions by 20-40 percent by 2030 relative to emissions in a baseline year (Parry, 2019).

A way to sanction nations who do not do their part has been a sticking point, but analysts say that was never really on the table. Instead, the agreement calls for a committee of experts to be formed to "facilitate implementation" and "promote compliance" with the agreement, but it would not have the authority to discipline violators (John D. Sutter, 2015).

Following the adoption of the Paris Agreement, in December 2018 at the UN climate conference (COP24), Katowice Rulebook was adopted, which includes common and comprehensive laws, procedures and guidelines for the operationalization of the Paris Agreement. It covers all main areas, including accountability, finance, mitigation and adaptation, and offers flexibility to parties who need it in the light of their capabilities, thus enabling them to execute and report on their commitments in an open, full, comparable and consistent manner. It will also enable the Parties to gradually increase their commitments to combating climate change in order to achieve the long-term objectives of the Agreement (Paris Agreement, n.d.).

The Paris Agreement does not discuss carbon pricing, but it is an important policy tool that is being used by an increasing number of countries and sub-national governments to curb emissions in order to help them meet their international climate commitments. Sweden was early on in pricing

carbon and in 1991 it established a carbon tax. The EU established a cap-and-trade system in 2005, and British Columbia implemented a carbon tax in 2008. Many other countries and jurisdictions around the world have since started to put a price on carbon (see Figure 5) (Carbon Market Watch, 2017).

For these reason, the use of carbon taxes is logical, since the key argument for carbon tax is that they are usually an important tool for meeting domestic commitments to curb emissions. As these taxes raise the prices of fossil fuels, electricity and general consumer goods and lower fuel producers' prices, they encourage, among other things, the transition to lower carbon fuels for power generation, energy efficiency and the switch to cleaner vehicles. A tax of, say, USD35 a ton on CO_2 emissions in 2030 would typically increase prices for coal, electricity, and gasoline by about 100, 25, and 10 percent, respectively. Carbon taxes also offer a strong incentive to shift investment in energy to low-carbon technology such as renewable power plants (Parry, 2019).

A USD35 per ton carbon tax alone would surpass the level required to meet mitigation obligations in countries such as China, India, and South Africa, as Parry (2019) claims in his paper, and it would be about right to fulfill commitments in Indonesia, the Islamic Republic of Iran, Pakistan, the United Kingdom, and the United States. However, in some countries, such as Australia and Canada, even a carbon tax as high as USD70 per ton (or equivalent measure) will fall short of what is required. These results reflect variations not only in the strictness of commitments but also in the responsiveness of emissions to taxes: in countries consuming a large quantity of coal, such as China, India, and South Africa, emissions are most responsive to carbon pricing.

The price level is the determining factor of whether or not the instrument can minimize pollution and have an effect on the environment. If a tax is set too low, it is easier for emitters to pay the tax and continue polluting rather than investing in emission-reducing technology; similarly, if the

ceiling in a cap-and-trade scheme is set too high, there would be insufficient scarcity in the system to generate a price that promotes emission reductions (Carbon Market Watch, 2017). Most jurisdictions with carbon prices have prices below USD10 a tonne, according to the International Monetary Fund (Parry, 2015, as cited in Carbon Market Watch, 2017).

It is difficult to put a price on the consequences of climate change, especially given the variety and degree of harm it causes: the loss of biodiversity, the cost of public health, the effect on labor productivity, the spread of tropical diseases, ocean acidification, rising sea levels, famine, severe weather events, and political instability. Nevertheless, preventing climate hazards is priceless and becomes more costly the closer we get to crucial climate tipping points. In any case, leading economists believe that any price estimate of the damage caused by greenhouse gas emissions is almost certainly too low (Carbon Market Watch, 2017).

Although carbon prices are rising in many jurisdictions, they remain significantly lower than those required to be in line with the Paris Agreement. However, there is an emerging consensus on the levels of carbon pricing required to achieve the objectives of the Paris Agreement, based on what we know is the cost of reducing emissions across sectors. The High-Level Commission on Carbon Prices estimated that carbon prices of at least USD40–80/tCO_2 by 2020 and USD50–100/tCO_2 by 2030 are required to cost-effectively reduce emissions in line with the temperature goals of the Paris Agreement. Less than 5% of the GHG emissions currently covered by carbon prices are within this range as of today (CPLC, 2017, as cited in World Bank, 2020), with about half of the covered emissions priced at less than USD10/tCO_2e, and the IMF estimates that the global average carbon price is only USD2/tCO_2 (IMF, 2019, as cited in World Bank, 2020). Local conditions and the role that the carbon pricing instrument should play, as well as the impact of other climate policies and technological progress, will determine the appropriate carbon price. Equally, as

companies become familiar with the new pricing policy, jurisdictions may choose to introduce a tax or an ETS with an initially low price that increases over time. Nevertheless, prices - similar to those reported in the previous two years - remain too low (World Bank, 2020).

Via international collaboration, a wide variety of public and private sector players are moving ahead with decarbonization strategies. Modeling has shown that collaboration under Article 6 of the Paris Agreement could reduce the cost of implementing NDCs by approximately half - equivalent to a savings of USD250 billion in 2030 - or reduce global GHG emissions by an additional 50 percent relative to countries that act alone (IETA, 2019, as cited in World Bank, 2020). However, progress on finalizing the rules for such international cooperation under Article 6 is slow, as they cover a range of issues that are not easily resolved, including the transition of credits from the Kyoto Protocol, the levy on transfers of mitigation results to finance adaptation measures in more vulnerable countries, and how to achieve global emissions mitigation overall. Nevertheless, pilots are beginning to provide valuable insights into how international collaboration can deliver robust pollution results and the criteria for infrastructure to control these activities (World Bank, 2020).

Most of the current carbon prices, as we described above, are far from the necessary levels. A popular example of a system that suffers from chronic over-supply and low prices is the EU ETS. There have also been low prices for the Regional Greenhouse Gas Initiative (RGGI) in the Northeastern United States. This is a common occurrence in many cap-and-trade schemes, although there are also many low-level taxes, which are presumably more successful at raising revenue than reducing emissions (Carbon Market Watch, 2017).

In line with the Paris Agreement goals, British Columbia and Sweden have especially effective carbon taxes. Both policies have provided robust price signals that have allowed them to

dramatically reduce emissions and expand their economies at the same time (Carbon Market Watch, 2017).

To summarize and present more comprehensively, up to this point we have (see as well figure 6):

Prices Needed For Paris:

- The US Interagency Working Group on the Social Cost of Carbon estimated USD50 of global damage per tonne in 2020 (Revesz et al., 2017, as cited in Carbon Market Watch, 2017);
- The High-Level Commission on Carbon Prices, a group of leading economists working with the Carbon Pricing Leadership Coalition, concluded that the explicit carbon price level consistent with achieving the Paris temperature target is at least USD40–80/tCO_2 by 2020 and USD50–100/tCO_2 by 2030 (World Bank, 2020);
- The IMF also forecasts that prices from USD50 to USD100 per tonne or more will meet their carbon-reduction target by 2030 (Carbon Market Watch, 2017);
- UK Climate Change Committee minimum price to reach 2050 goals: GBP 27 (USD 35.77)/tCO_2 in 2020 and rising through the 2020s to GBP 70 (USD 92.73)/tCO_2 in 2030 (Committee on Climate Change, 2010, as cited in Carbon Market Watch, 2017).

Current Carbon Tax Prices:

- British Columbia CAN$40/t$CO_2$e (USD28/ t$CO_2$e);
- Canada's federal backstop consists of two components: (I) a regulatory charge on fossil fuels set at CAN$20/t$CO_2$e (USD14/t$CO_2$e) in 2019 that rises by CAN$10/t$CO_2$e (USD7/t$CO_2$e) per year to CAN$50/tCO_2e (USD35/tCO_2e) in 2022; and (II) an Output-Based Pricing System (OBPS) that sets emission intensity standards for power generation and a wide range of activities;
- Sweden: SEK1190/tCO_2 (USD119/ tCO_2) in 2020;
- Finland: USD 58-68;
- Norway: NOK544/tCO_2e (USD53/tCO_2e);
- Denmark: USD 26;
- France: USD 49;
- Ireland: €26/tCO_2 (USD29/tCO_2).

Source: (World Bank, 2020) and (Carbon Market Watch, 2017)

The Paris Agreement continues to serve as a mechanism for increased climate action, as reported in the most recent report by the World Bank (2020). The Chilean COP presidency declared at COP 25 in Madrid, Spain in December 2019, that 120 UNFCCC parties, representing 20 percent of global GHG emissions, are working as part of the Climate Ambition Alliance to achieve net zero CO_2 emissions by 2050. As of 1 April 2020, Denmark, France, New Zealand, Sweden and the United Kingdom have included in their legislation a net zero CO_2 emissions target, and Suriname

and Bhutan are now carbon-negative. Legislation for a net zero emissions target has been suggested by Chile, the EU, Fiji and Spain. Moreover, 15 sub-national regions, 398 cities, 786 companies and 16 investors have also stated that they are working towards achieving net zero emissions goals. These commitments reflect the common awareness that current climate action plans are insufficient in reducing the risk climate change poses to society, our well-being and natural systems.

As of 1 April 2020, the Paris Agreement has been ratified by 195 parties and 189 have deposited their instruments of ratification 97 Parties are referring to carbon pricing in their NDCs, indicating that they are planning or considering the use of climate markets and/or domestic carbon pricing to fulfill their NDC commitments. 58 percent of global GHG emissions are accounted for by these 97 parties. The manner in which carbon pricing is implemented into the NDCs submitted varies (World Bank, 2020).

As governments across the globe implement more aggressive emission targets, domestic carbon pricing policies have been improved. This is especially relevant as 2020 and 2021 are crucial years for countries to scale up their Paris Agreement emission reduction commitments, with several countries, regions and cities announcing a "climate emergency" in the past year (World Bank, 2020).

Although more and more countries are adopting carbon pricing, the vast majority of global emissions are still not priced at all. However, even when carbon pricing strategies are in effect, price levels are often not sufficiently high to make a significant contribution to achieving the Paris Agreement objectives (Carbon Market Watch, 2017).

As Parry (2019) suggests in his paper, policymakers need carefully tailored steps to effectively fulfill their mitigation commitments for this international policy to succeed, while at the same time

limiting the strain on the economies of their countries and negotiating the political obstacles to implementation. However, even if successfully adopted, current country agreements would slash global emissions by just around one-third of the amount needed to achieve the objectives of climate stabilization. Therefore, novel strategies are required to scale up international-level mitigation efforts.

5. THE EUROPEAN (EU) WAY TO CARBON TAXATION

The concept of sustainable development, first adopted by the World Commission on Environment and Development (WCED) in the Brundtland Report (1987), sounds is as follows: *development which meets the needs of the current generations without compromising the ability of future generations to meet their own needs*. This is the concept is the most commonly used today. Following this report, the Rio Declaration on Environment and Development (1992), the World Summit for Social Development (1995), the Programme of Action of the International Conference on Population and Development (ICPD) (1994), the Beijing Platform for Action (1995), the Millennium Declaration (from which the Millennium Development Goals were derived), the World Summit on Sustainable Development (2002), the 2005 World Summit outcome and the UN Conference on Sustainable Development (Rio+20) in 2012 were among the key achievements in the international pursuit of sustainable development, paving the way for the 2030 Agenda (Eurostat, 2020).

The UN General Assembly (UNGA), in September, 2015 adopted the document "Transforming our world: the 2030 Agenda for Sustainable Development" document, which is the new global sustainable development agenda. The foundation of 2030 Agenda is a list of 17 Sustainable Development Goals (SDGs) and 169 related targets to end poverty, protect the planet, and ensure prosperity and peace (Eurostat, 2020).

The 17 SDGs are: (1) No Poverty, (2) Zero Hunger, (3) Good Health and Well-being, (4) Quality Education, (5) Gender Equality, (6) Clean Water and Sanitation, (7) Affordable and Clean Energy, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure, (10) Reducing Inequality, (11) Sustainable Cities and Communities, (12) Responsible Consumption and Production, (13) Climate Action, (14) Life Below Water, (15) Life On Land, (16) Peace, Justice, and Strong Institutions, (17) Partnerships for the Goals (Eurostat, 2020).

In terms of importance and scope, the SDGs are groundbreaking and go well beyond the UN Millennium Development Goals by setting a wide range of economic, social and environmental goals and calling for all countries to take action, regardless of their level of economic development. The Agenda stresses that policies to end poverty and encourage sustainable growth for everyone must go hand in hand with initiatives that address a broader spectrum of social needs and promote peaceful, just and inclusive communities, protect the environment and help tackle climate change. Although the SDGs are not legally binding, it is assumed that governments will take ownership of the 17 goals and set national mechanisms for achieving them (Eurostat, 2020).

All SDGs included in one or more of the six key ambitions for Europe, announced in the Political Guidelines (Von der Leyen, 2019, as cited in Eurostat, 2020), making all Commission work streams, policies and strategies conducive the achievement of the SDGs. His or her control represent and relate to the SDGs, whilst the Commissioners' college is collectively responsible for implementing the 2030 Agenda. The interconnectedness of the social, economic and environmental spheres has been demonstrated by the ongoing COVID-19 crisis, alerting us to the importance of achieving SDGs (Eurostat, 2020).

The SDGs have also been incorporated into the European Semester, in accordance with the Political Guidelines. The Annual Sustainable Growth Strategy began the 2020 annual cycle, focused on encouraging competitive sustainability to create an economy that works for people and the earth. The SDGs were also expressed in the country reports of the European Semester and in the country-specific guidelines following the Communication (European Commission, 2020, as cited in Eurostat, 2020), which cover four dimensions of competitive sustainability: stability, fairness, environmental sustainability and competitiveness (Eurostat, 2020).

SDG monitoring is performed at different levels: national, regional, global and thematic. The UN High Level Political Forum (HLPF) is the UN's central platform for the global monitoring and analysis of the 2030 Agenda and the SDGs. To this end, the 2030 Agenda promotes the execution of voluntary national assessments of progress towards the SDGs by UN Member States. The HLPF's regular reviews are voluntary, state-led, carried out by both developed and developing countries and provide a forum for collaborations, including through the involvement of major groups and other related stakeholders. In view of this, on the basis of the 2030 Agenda, several countries are updating their national sustainable development strategies (Eurostat, 2020).

A collection of global indicators was developed by the Inter-Agency and Expert Group (IAEG-SDGs) under the oversight of the UN Statistical Commission in order to follow up and review the objectives and targets (Eurostat, 2020).

It is critically dependent on a global partnership to mobilize means of implementation, including financial and non-financial capital, to achieve the SDGs around the world. Therefore, the mobilization of capital for sustainable development is another essential aspect of the 2030 Agenda, in addition to the definition of priorities and goals and the development of a global list of indicators (Eurostat, 2020).

A key policy goal for the European Union, enshrined in its treaties since 1997, has long been sustainable development. The first EU Sustainable Development Strategy, implemented in 2001, set out a single, comprehensive roadmap on how to solve the EU's sustainable development challenges. The European Council adopted the Europe 2020 Plan in June 2010, the EU's roadmap for development and jobs for the current decade. Three mutually reinforcing core priorities of smart, sustainable and inclusive development, steered by the European Semester process, have been put forward in the Europe 2020 strategy. For each of the three key priorities, the strategy

defined one or more targets in five areas: (1) employment, (2) research and development (R&D) and innovation, (3) climate change and energy, (4) education and (5) poverty and social exclusion (Eurostat, 2020).

The work leading up to the adoption of the UN 2030 Sustainable Development Agenda in 2015 has given rise to a new impetus for policy action in this region, both globally and within the EU and its Member States. In November 2016, the European Commission adopted its Communication on "Next Steps towards a Sustainable European Future: European Action for Sustainability" in response to the 2030 Agenda, announcing a two-step approach to the implementation of the SDGs. Full incorporation of the SDGs into the European policy system and Commission priorities has been the first work stream. The second work stream has been a reflection on further progress of the EU's post-2020 longer-term vision. In this regard, the Commission presented in January 2019 a reflection paper "Towards a Sustainable Europe by 2030" (Eurostat, 2020).

A comprehensive periodic monitoring of the SDGs in the context of the EU from 2017 onwards was also announced in the 2016 Communication, which led to the establishment of the EU SDG Indicator set and the launch of the annual EU SDG monitoring reports in November 2017 (Eurostat, 2020).

The reflection paper "Towards a Sustainable Europe by 2030" has based its evaluation of EU success with regard to the SDGs on the 2018 EU SDG monitoring report and other related sources. It recognizes the EU's competitive advantages that give the EU the ability to demonstrate leadership and highlight the direction to be taken by others. Powerful welfare systems, substantial investment in science and innovation, and very high social, health and environmental standards are among these advantages. The paper also highlights the complex and interrelated challenges facing the EU, especially with regard to climate change and ecological debt, technological and

demographic change, inequality and social cohesion. Many elements of this reflection paper were taken up in the Political Guidelines of the von der Leyen Commission and the mission letters of individual Commissioners (Eurostat, 2020).

In December 2019 the European Commission presented the European Green Deal - a collection of policy initiatives that aim to make Europe the first climate-neutral continent by 2050 (Eurostat, 2020).

The European Green Deal is a new European growth plan with the goal of transforming the EU into a fair and productive society with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases by 2050 and economic growth is decoupled from the use of energy. It also aims to protect, conserve and improve the natural resources of the EU and protect citizens' health and well-being from threats and impacts relevant to the climate. This transition, at the same time, strives to be just and inclusive. The adoption of the 2030 Agenda and the SDGs is also seen as an important part of the Commission's strategy (Eurostat, 2020).

The European Green Deal's policy proposals include, but are not limited to, reductions in greenhouse gas emissions, a new circular economy action plan, a Just Transition Mechanism to leave no one behind, building renovations to achieve energy efficiency, a strategy for sustainable and smart mobility, a sustainable food strategy ("Farm to Fork" strategy), a new biodiversity strategy, a zero pollution action plan and a European Climate Pact that will allow Member States, stakeholders and citizens to better coordinate their actions. In addition, it outlines the required investments and available financing resources (Eurostat, 2020).

In order to achieve its ambitious aim of achieving a zero carbon footprint by 2050, the European Commission identified seven strategic building blocks to be pursued jointly by Member States (González, 2020):

- *Energy efficiency*: Residential and service buildings account for 40% of the EU's energy use, so refurbishing housing stocks is key to improving energy efficiency standards. The extent of this action is particularly remarkable in view of the fact that approximately 75% of all buildings in the European Union were constructed before existing energy efficiency requirements existed (González, 2020);
- *Deployment of renewables*: By encouraging the production of renewable energy sources, the target is to reduce Europe's energy dependency on imports from the current 55% to about 20% by 2050. This move would also help improve energy security and domestic employment levels, in addition to its obvious environmental benefits (González, 2020);
- *Clean, safe and connected mobility*: A quarter of the EU's overall greenhouse gas emissions are actually accounted for by transport. Prioritizing sustainable urban transportation alternatives, such as public transit or cycling, as well as upgrading current vehicles and means of transport, encouraging the use of low- and zero-emission technologies, would be important to curb this large footprint (González, 2020);
- *Competitive industry and circular economy*: To curb its greenhouse gas emissions, the European Union is aware of the need to modernize industrial development. This includes recycling as a key element in promoting the efficient use of resources, especially with regard to sectors and technologies that rely on materials that are produced in a few non-EU countries, such as cobalt or graphite (González, 2020);

- *Infrastructure and interconnections*: Owing to the need to find synergies at European level to change the transport market, this argument is closely linked to mobility. This entails the need for the creation of pan-European energy networks (González, 2020);
- *Bio economy and natural carbon sinks*: With the prospect of turning biomass into biofuels or biogas, biomass will play a key role in replacing the most polluting materials in heat production applications (González, 2020);
- *Tackle remaining CO_2 emissions with capture and storage*: Finally, the European Commission emphasizes the need to encourage research aimed at developing technologies for carbon capture and storage. These systems, capable of separating, storing and isolating the industry's carbon dioxide, are currently extremely costly. Indeed, a 2018 report by the European Academies' Scientific Advisory Committee ruled them out as a solution to the climate crisis. However, the European Union notes that the main solutions mentioned above should be complementary in those cases where emissions are difficult to eradicate (González, 2020).

The goal of becoming climate neutral by 2050 would be accomplished through the European Climate Law. The European Union is committed to a climate policy that is very ambitious - it aims to become the first continent under the Green Deal to eliminate as much CO_2 emissions as it consumes by 2050. This aim would become legally binding if the new Climate Law is accepted by the European Parliament and Council. It will also change the EU interim emission reduction goal for 2030 from the existing 40 percent reduction to a more aggressive one (European Parliament, 2020).

On 7 October 2020, relative to 1990 levels, the European Parliament endorsed climate neutrality by 2050 and a 60 percent carbon reduction goal by 2030 - more ambitious than the 55 percent

Commission plan. Members of the European Parliament (MEPs) are calling for an additional interim deadline for 2040 to be set by the Commission in order to ensure progress towards the final aim (European Parliament, 2020).

Additionally, members called for all EU countries to become climate neutral on an individual basis and insisted that more CO_2 should be eliminated from the atmosphere than released after 2050. Both direct and indirect fossil-fuel subsidies should also be phased out by 2025 at the latest (European Parliament, 2020).

As an independent scientific body, MEPs also want to set up an EU Climate Change Council (ECCC) to determine whether policy is compatible and to track progress. Parliament will then commence talks with the Council. The climate neutrality target is currently set by five EU countries: Sweden seeks to achieve net zero emissions by 2045 while Denmark, France, Germany and Hungary by 2050 (European Parliament, 2020).

In the EU context, the European Commission is committed to tracking progress towards the SDGs. In close cooperation with other Commission services and Member State organizations within the European Statistical System (ESS), Eurostat led the creation of a reference indicator framework for this purpose (Eurostat, 2020).

Figure 7 offers a statistical overview of the progress of the EU towards the SDGs over the last five years of available data, based on the average ratings of the measures chosen to track these targets in the sense of the EU. Throughout this five-year period, the EU has made progress towards almost all its objectives. Progress has been quicker in some targets than in others, and there have been a range of objectives moving away from the goals of sustainable development in particular fields. The aggregation of the individual indicator trends shows stagnation or a modest shift away of the

EU from the respective SD goals over the past five years for two objectives - SDG 13 “Climate action” and SDG 5 "Gender equality" (Eurostat, 2020).

As the figure shows (see figure 7) the EU has made significant progress in promoting peace and personal protection, access to justice and confidence in institutions (SDG 16). Progress was markedly slower against the other objectives. Out of the remaining goals, good progress over the past five years was visible in reducing certain aspects of poverty (SDG 1) and in improving the health situation of the EU population (SDG 3). The improvement in these fields has also led to improving the quality of life in cities and neighborhoods (SDG 11). These optimistic developments can be seen in the light of the continued improvement in the economic situation of the EU up to 2019, which has also been reflected in the labor market (SDG 8). Improvements in the viability and sustainability of the EU agriculture sector have also been evident (SDG 2), although some of its environmental impacts have escalated further (Eurostat, 2020).

The figure, on the other hand, indicates that priorities dealing with environmental aspects of sustainability are put at the other end of the continuum, suggesting overall slow to no progress made by the EU over the past few years. Progress towards the EU environment and energy goals (SDG 7 and SDG 13) has slowed to varying degrees, as has the transition towards a circular economy (SDG 12). In the meantime, ecosystems and biodiversity (SDG 15) remain under pressure from human activities (Eurostat, 2020).

The objectives for education (SDG 4), innovation (SDG 9) and global partnerships (SDG 17) represent the similarly slow overall development of the EU as a result of mixed patterns over the past five years. Slow progress towards reducing inequality (SDG 10) represents an increasing gap in poverty and jobs between EU nationals and non-EU residents. Similarly, the gap between men and women in education and in the labor market has been widening in relation to gender equality

(SDG 5). As SDG 5 shows more unfavorable than favorable trends for the EU, overall improvement over the past five years has been moderately unsustainable (Eurostat, 2020).

For two goals - SDG 6 “clean water and sanitation” and SDG 14 “life below water” – the overall EU patterns cannot be determined because of inadequate data for the past five years (Eurostat, 2020)

The current pandemic of COVID-19 is likely to have negative effects for the overall success of the EU towards the SDGs. However, Eurostat's 2020 SDG monitoring report only defines the situation in the EU and its Member States up to 2019 at most, the year before the EU Member States had widely adopted COVID-19 containment measures. Consequently, the first results of any impact relevant to COVID-19 will only be possible in the 2021 edition of the report, as reported in the current Eurostat (2020) report, with only later editions disclosing the full extent of the crisis.

Due to international standardization, Environmental Management Systems (EMS) that integrate the management of certain activities of an organization that have or may have an impact on the environment, have gained considerable attention in last years. BS 7750, created by the British Standards Institute and published in 1994, initially led the way. At the European level, the European Eco-Management and Audit Scheme (EMAS) followed suit. Lastly, on a global scale, ISO 14001 was launched (Malinovski & Samardziev, 2002).

EMAS was adopted in June 1993 by the European Council and approved voluntary participation in an EU-wide environmental management system based on harmonized lines and principles (Malinovski & Samardziev, 2002).

The ultimate goal of the scheme is to encourage on-going environmental performance enhancements. The framework obliges organizations to analyze and enhance their environmental performance and to provide the public with relevant information. Originally, the scheme was open

to industrial enterprises operating in the EU and the European Economic Area (EEA), but was subsequently revised in March 2001 with an enlarged framework including all sectors of economic activity, including local authorities. ISO 14001 was implemented as the EMAS environmental management framework by the amended EMAS regulations (Malinovski & Samardziev, 2002).

The ISO 14001 standard was developed to assist an organization in adopting or developing its system of environmental management. The norm accepts that companies should be concerned with both their sustainability and environmental impact management. In order to create an efficient Environmental Management System, ISO14001 combines these two motivations and offers a refreshingly workable approach. In practice, the standard offers a management methodology for the use of resources and their disposal. It is recognized worldwide as a means to control costs, reduce risks, and improve performance (Malinovski & Samardziev, 2002).

The standard does not set values for results. It offers a way of setting and maintaining performance commitments systematically. In other words, it is concerned with deciding "how to" accomplish an objective, not "what" the objective should be (Malinovski & Samardziev, 2002).

Its voluntary nature is the main feature of these standards. Voluntary means, in this case, that there is no legal obligation to comply with them. This is not to suggest that a company may not require its suppliers to comply with its EMS specifications, thus establishing a de facto requirement. The structure of the ISO 14001 standard, as well as the most EMS models, reflects the Plan, Do, Check, Act (PDCA) Deming cycle (Malinovski & Samardziev, 2002).

The study conducted by Iraldo, Testa and Freya in 2009 examined whether or not the EMS introduced in the EU under the EMAS Regulation had any environmental and competitive effects on firm results. A positive effect of a well-designed environmental management system on environmental efficiency and, as a result, on technological and organizational advances was shown

by their econometric analysis. The impact on other competitive factors are not strongly endorsed, such as market efficiency, resource productivity and intangible assets.

The study concluded that Environmental Management Systems have not yet reached a high degree of "maturity" in their implementation, considering the several years of their application. For other aspects, the EMS tends to be applied in a more systematic and efficient manner by EMAS-registered organizations. Environmental planning skills, for example, are typically stronger and well "rooted" in the enterprise and can thus yield beneficial impact on environmental results. This confirms that an actual increase in results can only be accomplished when certain components of an EMS that can be completely incorporated into the company's management dynamics begin working effectively (Iraldo, Testa, & Freya, 2009).

Another important result emerged from the study concerning the role of EMAS in improving competitive performance of the registered organizations. The adoption of an EMS according to EMAS specifications certainly provides a strong catalyst for the organization's innovation capabilities, but the study also explicitly emphasizes that it is not a necessary condition to simply implement EMAS. The outcome showed that organization can only achieve stronger innovation capabilities if it obtains a real improvement in environmental performance by way of its EMS (Iraldo, Testa, & Freya, 2009).

For taxing carbon emissions EU uses Emissions Trading System (EU ETS) which was implemented in 2005 as the cornerstone of its policy to curb carbon dioxide (CO_2) emissions and other greenhouse gases at least cost. The EU ETS is the first big carbon market in the world and remains the largest today by far. The EU ETS has brought climate change on the agenda of corporate boards across Europe by placing a price on carbon and thus providing a financial value to each ton of emissions saved. Carbon pricing also encourages investment in low-carbon,

renewable technology. The EU ETS acts as a catalyst of investment in renewable technology and low-carbon solutions globally by enabling businesses to purchase credits from emission-saving projects around the world, in particular in the least developed countries (Commision, 2016).

The EU ETS works on the cap-and-trade principle. The cumulative amount of greenhouse gases that can be emitted for a multi-year phase by the power plants, factories and other companies covered by the system is subject to a cap set at EU level. Within this cap, companies receive or buy emission allowances which they can trade, if they wish to do so (Commision, 2016).

In the 2013-2020 period, pollution limits from power stations and other fixed installations were reduced annually by 1.74 percent. A separate cap was introduced to the aviation sector: this was 5 percent below the average annual emissions level for the entire 2013-2020 period in the years 2004-2006. Emission allowances are the *currency* of the EU ETS and are assigned a value by the cap on the total number available. Each allowance grants the holder the right to emit one ton of CO_2, the principal greenhouse gas, or the equivalent of two other potent greenhouse gases, nitrous oxide (N2O) and perfluorocarbons (PFCs), respectively. Allowances can only be used once. For each ton of CO_2 (or the equivalent volume of N2O or PFCs) protected by the EU ETS they emitted in the previous year, companies must surrender allowances. If they do not hand in enough permits to balance their pollution, heavy fines are levied. Companies may obtain such allowances for free from governments. In order to offset the remainder of their emissions, they must: buy new allowances or/and draw on any excess allowances they have saved from previous years (Commision, 2016).

The need to purchase or draw on their reserves of allowances and credits creates a permanent incentive for companies to reduce their emissions by investing in more efficient technology or shifting to less carbon-intensive energy sources. Companies can also sell allowances and credits,

for instance if they judge they have more than they are going to need. This allows them to choose the most cost-effective options to address their emissions (Commision, 2016).

The EU ETS focuses on emissions that can be measured, reported and checked to a high degree of precision, while emissions trading has the ability to cover many economic sectors and greenhouse gases. Participation in the EU ETS, which is interpreted as an agreement to surrender allowances for recorded pollution, is obligatory for companies operating in the sectors covered, although only plants over a certain scale are covered in certain sectors. If fiscal or other policies are in place that will reduce their emissions by an equal amount, governments may exempt such small installations from the system. The EU ETS also covers emissions from aviation (Commision, 2016)

Development of EU ETS contains four phases:

- *2005-2007: 1st trading period* was a "learning by doing" process. EU ETS was successfully established as the biggest carbon market in the world. However, based on expected needs, the number of allowances turned out to be excessive; as a result, the price of first-period allowances fell to zero in 2007;
- *2008-2012: 2nd trading period*. Iceland, Norway and Liechtenstein joined (01.01.2008). The number of allowances has decreased by 6.5 percent over the period, but the economic downturn has further depressed emissions and thus demand. This has resulted in a surplus of unused allowances and credits that continue to weigh on the price of carbon. Aviation has been integrated into the scheme (01.01.2012);
- *2013-2020: 3rd trading period.* Important changes took place (01.01.2013), which were the implementation of an EU-wide cap on emissions (reduced by 1.74 percent per year) and a gradual transition towards the auctioning of allowances instead of the free allocation of costs. Croatia joined the ETS (01.01.2013);

- *2021-2030: 4th trading period.* In July 2015 legislative proposal for the revision of the EU ETS was presented by the European Commission.

Source: (Commision, 2016)

In 2019, policy makers worked ahead of the next trading period (2021-2030) to introduce provisions in line with the updated ETS Directive. New regulations on the carbon leakage list, the guidelines for free allocation, the Innovation Fund, auctioning, MRV (Monitoring, Reporting and Verification) and accreditation, and the Union Registry have been introduced (World Bank, 2020). Carbon leakage refers to the situation that may arise if companies move production to other countries which have laxer limits on greenhouse gas emissions for climate policy-related cost reasons. This may result in a rise in their overall emissions. In some energy-intensive industries, the probability of carbon leakage could be higher. The sectors and sub-sectors considered to be exposed to a serious risk of carbon leakage are officially identified. There are about 170 sectors and subsectors on the existing list, covering a very high share of industrial pollution. On the basis of clearly specified parameters and after thorough consultation with stakeholders, the list shall be created for a period of five years (Commision, 2016).

The market stability reserve (MSR), the mechanism to resolve the supply-demand imbalance of allowances in the EU ETS and strengthen its resilience to future shocks, became operational on January 1, 2019. In 2019, 397 million allowances were put in the MSR intended for auctions, reducing the availability of allowances in the EU ETS market. Another 265 million allowances are due to be put in the reserve from January to August 2020. Allowances kept in the MSR are not indefinitely excluded from the market, even if the total amount of allowances in the MSR is restricted to the previous year's auction volume as of 2023 (World Bank, 2020).

According to the World Bank (2020) report, the introduction of the reserve has helped stabilize the EU allowance (EUA) price around EUR25/tCO2e (USD27/tCO2e) over 2019, after increasing from €5–10/tCO2e (USD5–11/tCO2e) over the previous two years. However, the economic downturn caused by COVID-19 has seen a drop in EUA prices in the first quarter of 2020 to €17/tCO2e (USD19/tCO2e).

The UK also officially withdrew from the EU ETS after its withdrawal from the EU on 31 January 2020. However, the UK was still active in the EU ETS during the transition phase until the end of 2020 (European Commission, 2020, as cited in World Bank, 2020).

The European Commission published a negotiating mandate at the beginning of February 2020 to start negotiations with the UK on a post-Brexit agreement. The mandate encourages parties to consider linking the UK national ETS with the EU ETS (European Commission, 2020, as cited in World Bank, 2020). To ensure a fair playing field and the credibility of the EU ETS, linking will have to be based on conditions accepted within the EU, as it is stated by World Bank (2020).

The Commission will review and recommend, as part of the EU Green Deal, in line with the EU's commitment to carbon neutrality by 2050, as enshrined in the proposed European Climate Law, to amend, where applicable, all related climate policy instruments by June 2021. This includes the EU ETS and a potential expansion to new areas of emissions trading. In addition, negotiations on the implementation of a carbon border adjustment mechanism to reduce the risk of carbon leakage for selected sectors have begun, and a legislative proposal is scheduled for mid-2021 (European Commission, 2019, as cited in World Bank, 2020). Sectors would include those historically vulnerable, such as the steel industry, to carbon leakage. The change to the carbon border will offer an alternative to current steps to address the possibility of carbon leakage due to the EU ETS: free allocation and reimbursement for indirect carbon costs in electricity prices. A carbon tax on

selected products, a new carbon customs duty or a tax on imports or an extension of the EU ETS to imports could be a number of options. The methodological considerations for introducing the border adjustment system could be similar to those already existing as part of the EU ETS, i.e. a benchmarking adjustment. Alternative approaches will also be discussed by the European Commission, including taking into account the relationship of the carbon content of products with current and future climate policies (World Bank, 2020).

As reported in the World Bank's (2020) report, plans for carbon border adjustments in Europe have begun to shake up the global environment and trade debate. Carbon border adaptation mechanisms provide an alternative means of ensuring a level playing field between products manufactured within a jurisdiction and imported goods in terms of the cost of GHG emissions associated with the manufacture of such goods. This may help to raise support for domestic climate action, but also inspire other countries to adopt climate policies of their own.

The mechanisms are aimed at resolving competitiveness issues and preventing carbon leakage due to the disparity in the cost of climate policy faced by businesses operating in the same market. Theoretically, the modification of the carbon border will protect pollution-intensive, trade-exposed industries from competition from cheaper imports from countries with less strict climate policies, while retaining incentives to reduce their emissions for those industries. The adjustment mechanism can usually take two forms: either tariffs on products imported from jurisdictions where businesses face lower or no carbon costs, or rebates on the carbon costs of goods exported to markets where businesses compete with those that are not subject to similarly strict climate policies. A carbon border adjustment proposal, when incorporated into an ETS, may require importers to surrender adequate allowances to cover embedded GHG emissions from the

manufacture of their products. Alternatively, it may be levied on both international and domestic producers as a jurisdiction-wide tax, or as an import levy (World Bank, 2020).

Although this option has been debated repeatedly in the literature on carbon pricing, it has not been introduced in practice yet. Research has shown that changes to the carbon boundary are potentially effective in resolving carbon leakage while preserving environmental effectiveness (World Bank, 2015). However, functional feasibility, administrative obstacles to the measurement of the carbon intensity of manufactured products, and incompatibility with the laws of the World Trade Organization (WTO) impede implementation. Nevertheless, studies have shown that through careful design and execution, there are different paths to conquer these obstacles (Climate Strategies, 2017, as cited in World Bank, 2020).

6. CONCLUSIONS

Analyses of the literature, including two most recent reports by the World Bank and Eurostat, has shown that scientists believe that global warming is the result of carbon emissions from coal, oil, and other fossil fuels. There is no question that we face the possibility of catastrophic climate change if we fail to reduce greenhouse gas emissions significantly over the next ten to twenty years.

In order to address the challenge of reducing emissions of carbon dioxide and to promote the development of renewable energy sources, the global climate crisis calls for industry to innovate. It is critical that the world takes effective and decisive action in order to minimize greenhouse gas emissions.

Market-based methods that put a price on emissions are especially appealing in the fight against climate change. Setting such a price will make it easier for the market to do what it does best: allow customers and companies to cut emissions at the lowest cost and provide innovators with a continuous incentive to find new ways of reducing carbon emissions. Carbon tax is the most compelling among market-based approaches.

Carbon tax levied on all coal, natural gas and oil produced domestically or imported into the country is an effective and efficient solution to reduce the carbon dioxide emissions. A carbon tax will make it possible for the economy to pay for the societal costs of producing carbon dioxide and thereby contribute to reducing emissions. Important arguments for carbon tax are: they are straightforward to administer, they could raise a significant amount of revenue and also can generate significant domestic environmental benefits.

According to the World Bank's (2020) report. There are now 61 carbon pricing initiatives in place or scheduled for implementation, consisting of 31 ETSs and 30 carbon taxes.

Significant reductions in greenhouse gas emissions must occur over the next ten to twenty years in order to avoid the worst effects of global warming. Climatologists warn that we must restrict global warming to about 2 ° C or 4 ° F to avoid catastrophic environmental consequences. Overall framework for international cooperation to tackle climate change and specifically to keep the increase in the global average temperature to well below 2 °C with best efforts to restrict warming to 1.5 °C and to reach net zero emissions by 2050 is given by the Paris Agreement - the world's first universal, legally binding international climate change treaty.

Although carbon prices are rising in many jurisdictions, they remain significantly lower than those required to be in line with the Paris Agreement. About half of the covered emissions are priced at less than USD10/tCO_2e, and the global average carbon price is only USD2/tCO_2.

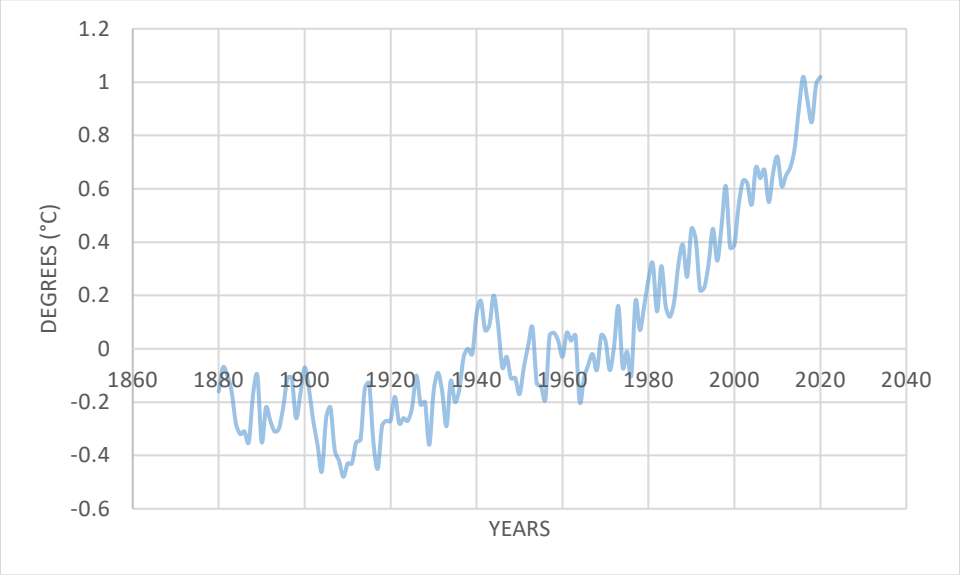
Analysis shows that a carbon tax that is set at the proper level can adequately stimulate innovation in clean technology and the transition from a high to a low-carbon economy. Such a carbon tax should equal to the *social cost of carbon*, measuring the total damage from an additional ton of carbon pollution.

In line with the Paris Agreement goals, British Columbia and Sweden have especially effective carbon taxes. Their examples demonstrate that carbon pricing can indeed work without affecting economic development, while reducing emissions. A popular example of a system that suffers from chronic over-supply and low prices is the EU ETS.

In conclusion, it can be said that carbon taxes are widely adopted as the most effective means for carbon emissions reduction, but the impact of the tax on social welfare and economic growth, as it was not the subject of the current study investigation essentially stays obscure and conceivable subject for future examination.

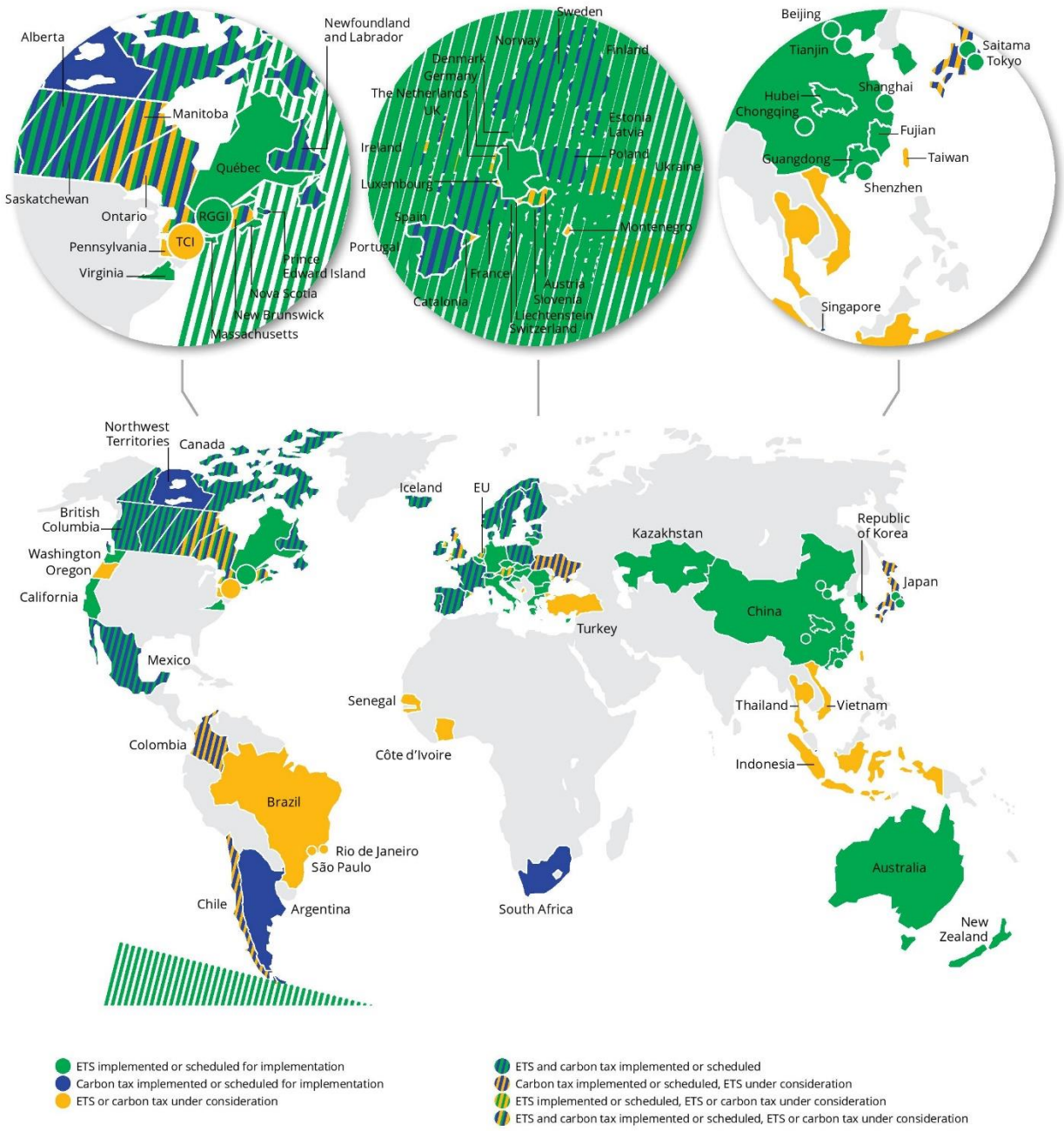
FIGURES

Figure 1: Change in Global Land-Ocean Temperature 1880-2020 (^{0}c degrees)



Source: (GISTEMP Team, 2021) and (Lenssen, et al., 2019)

Figure 2: Carbon pricing initiatives implemented, scheduled for implementation and under consideration (ETS and carbon tax)



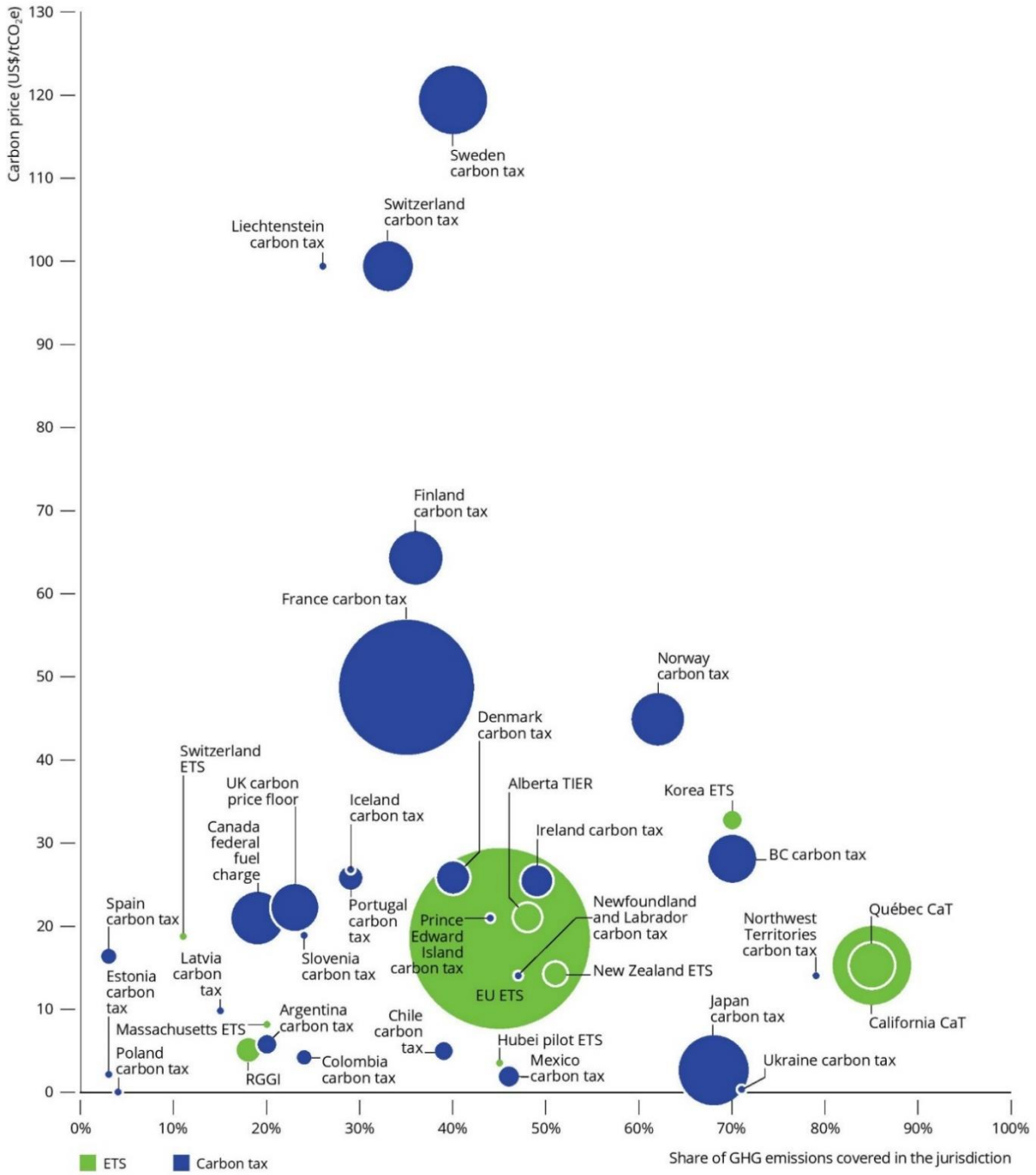
The large circles represent cooperation initiatives on carbon pricing between subnational jurisdictions. The small circles represent carbon pricing initiatives in cities.

Note: Carbon pricing initiatives are considered "scheduled for implementation" once they have been formally adopted through legislation and have an official, planned start date.

Carbon pricing initiatives are considered "under consideration" if the government has announced its intention to work towards the implementation of a carbon pricing initiative and this has been formally confirmed by official government sources. The carbon pricing initiatives have been classified in ETSs and carbon taxes according to how they operate technically. ETS not only refers to cap-and-trade systems, but also baseline-and-credit systems as seen in British Columbia and baseline-and-offset systems as seen in Australia. The authors recognize that other classifications are possible.

Source: (World Bank, 2020)

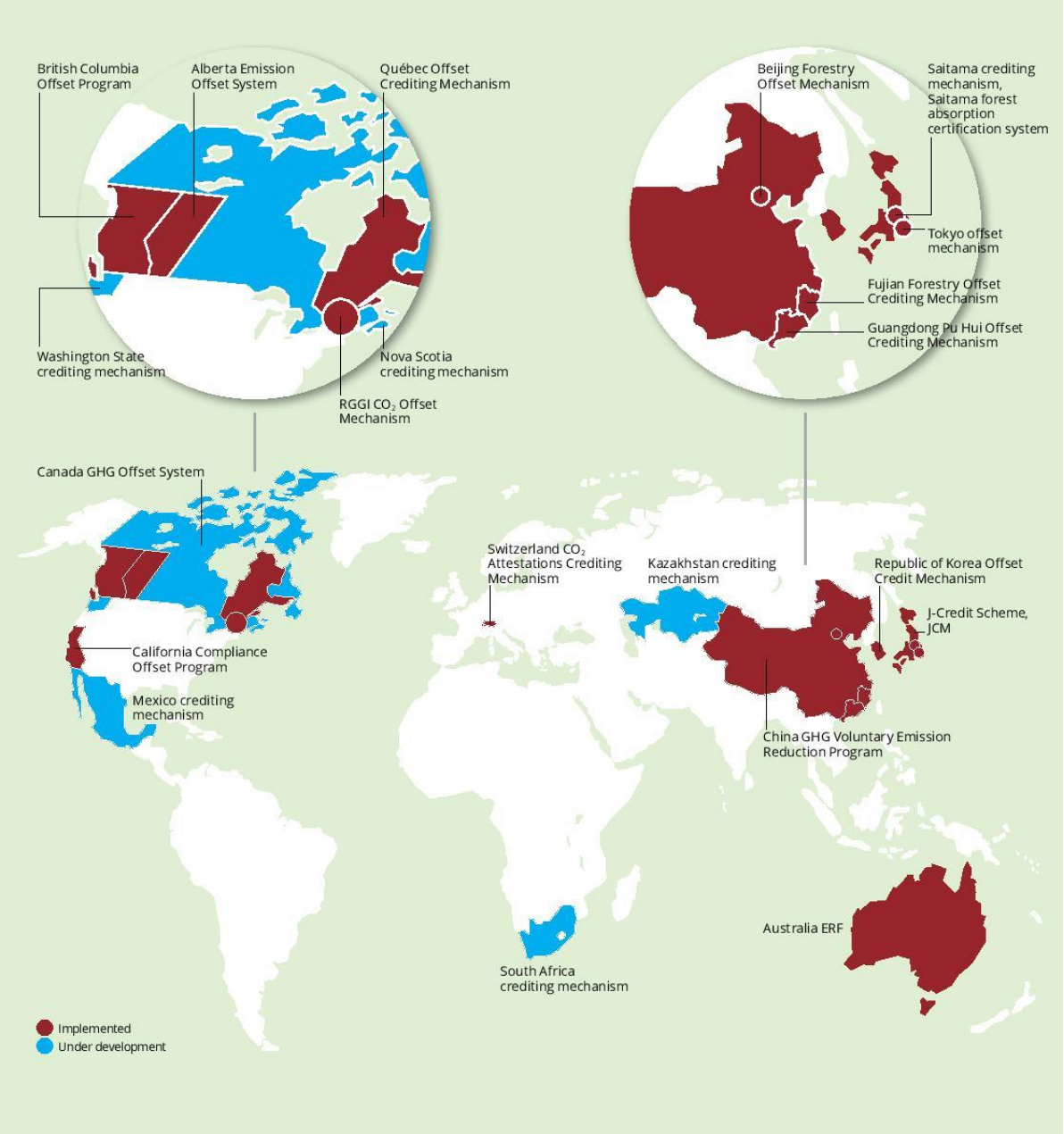
Figure 3: Carbon price, share of emissions covered and carbon pricing revenues of implemented carbon pricing initiatives



Note: Government revenues from carbon taxes, auctioned allowances and direct payments to meet compliance obligations. The size of the circles is proportional to the amount of government revenues except for initiatives with government revenues below USD100 million in 2019; the circles of these initiatives have an equal size. For illustrative purposes only, the nominal prices on April 1, 2020 and the coverages in 2020 are shown. The carbon tax rate applied in Argentina, Finland, Ireland, Mexico and Norway varies with the fossil fuel type and use. The carbon tax rate applied in Denmark and Iceland varies with the GHG type. The graph shows the average carbon tax rate weighted by the amount of emissions covered at the different tax rates in those jurisdictions. The middle point of each circle corresponds to the price and coverage of that initiative.

Source: (World Bank, 2020)

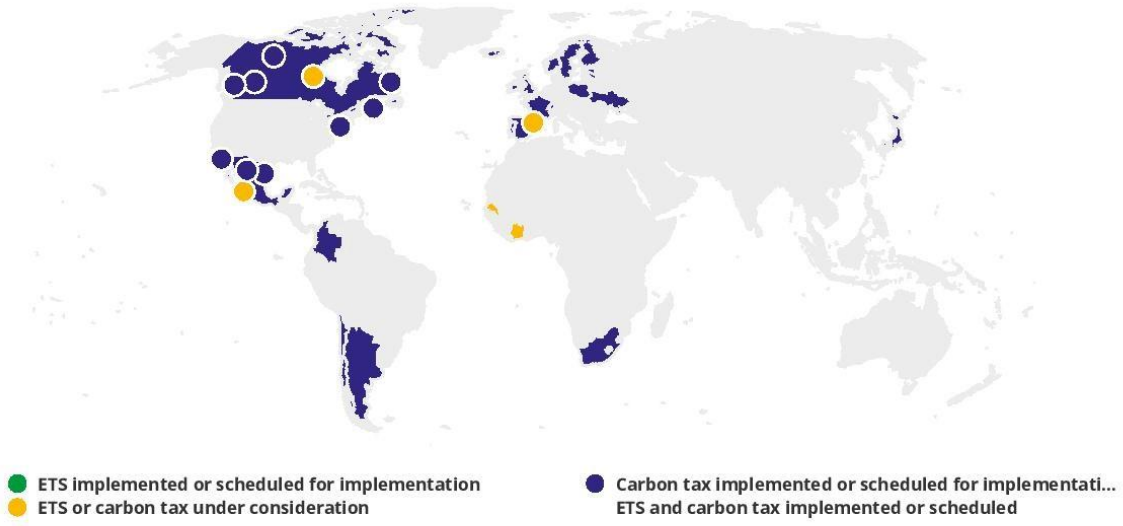
Figure 4: Status of regional, national and subnational crediting mechanisms



Note: The large circles represent cooperation initiatives on crediting between subnational jurisdictions. The small circles represent crediting mechanisms in cities. JCM = Joint Crediting Mechanism. RGGI = Regional Greenhouse Gas Initiative.
Implemented crediting mechanisms have the required legislative mandate as well as the supporting procedures, emission reduction protocols and registry systems in place to allow for crediting to take place. Crediting mechanisms are considered to be under development if they have legislature in place allowing for the future implementation of carbon crediting system but has currently not issued any credits either due to missing components such as registries and protocols. The authors recognize that numerous other independent crediting mechanisms exist that generate credits sold on the voluntary carbon market.
Crediting mechanisms implemented: National: China GHG Voluntary Emission Reduction Program, J-Credit Scheme, Republic of Korea Offset Credit Mechanism, Switzerland CO_2 Attestations Crediting Mechanism. *Subnational:* Fujian Forestry Offset Crediting Mechanism, Guangdong Pu Hui Offset Crediting Mechanism, Québec Offset Crediting Mechanism, Saitama crediting mechanism, Saitama forest absorption certification system, Tokyo offset mechanism. *Crediting mechanisms under development*: *National:* Canada GHG Offset System, Kazakhstan crediting mechanism, Mexico crediting mechanism, South Africa crediting mechanism. *Subnational:* Nova Scotia crediting mechanism, Washington State crediting mechanism.

Source: (World Bank, 2020)

Figure 5: Summary map of regional, national and subnational carbon pricing initiatives



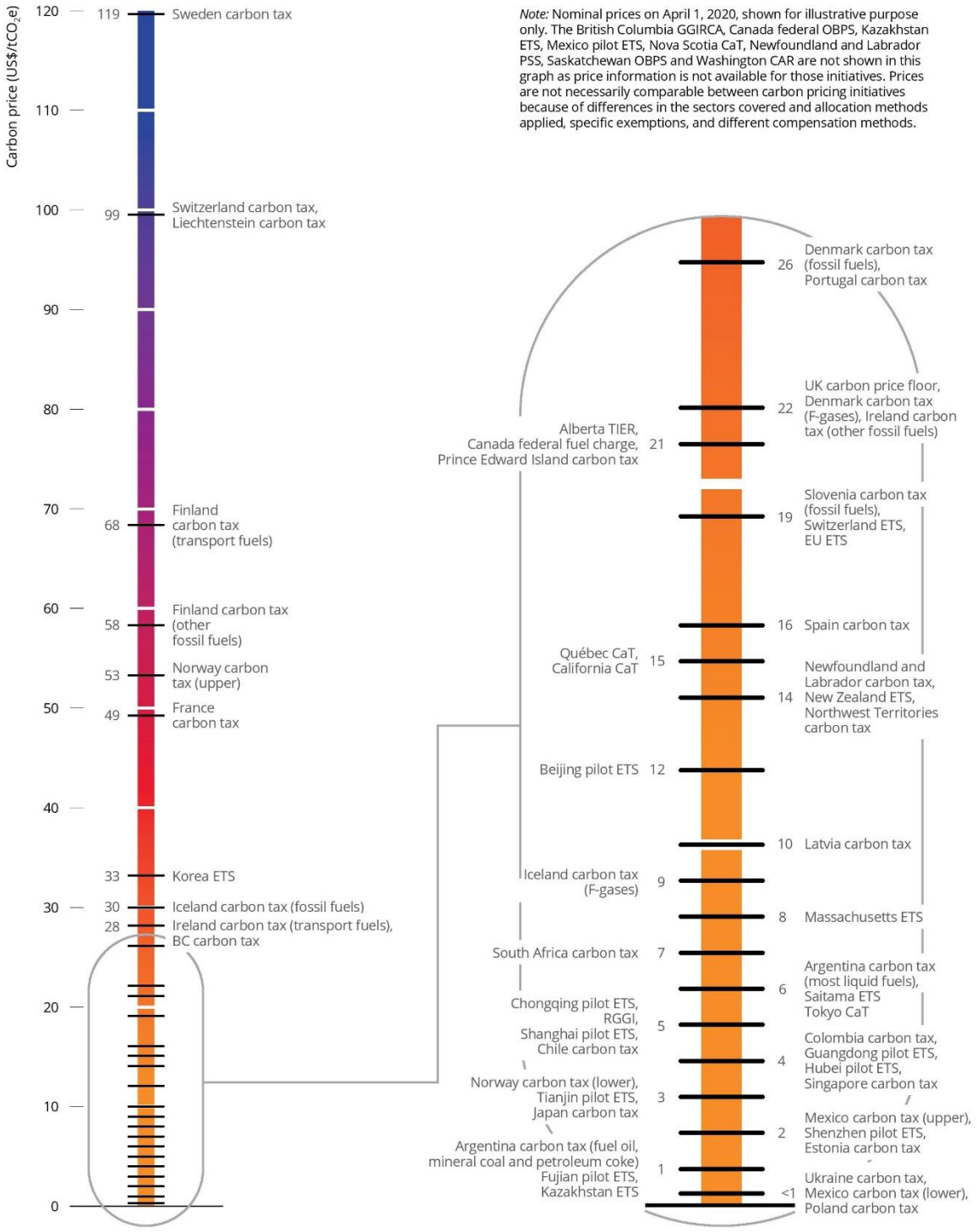
Source: (Carbon Pricing Dashboard, The World Bank, 2020)

Note: Carbon pricing initiatives are considered "*scheduled for implementation"* once they have been formally adopted through legislation and have an official planned start date. (Carbon Pricing Dashboard, The World Bank, 2020)

Carbon pricing initiatives are considered *"under consideration"* if the government has announced its intention to work towards the implementation of a carbon pricing initiative and this has been formally confirmed by official government sources. (Carbon Pricing Dashboard, The World Bank, 2020)

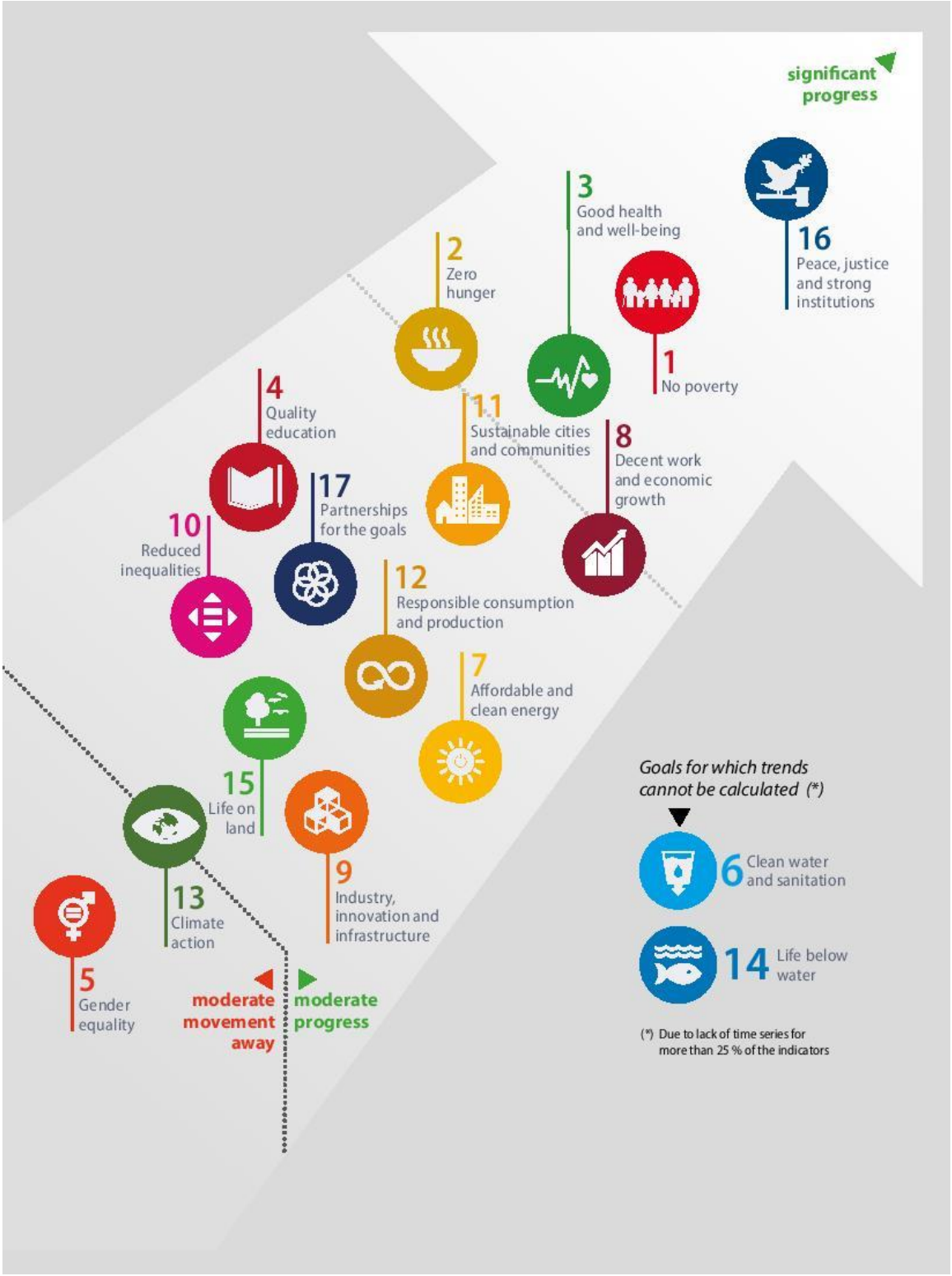
Jurisdictions that only mention carbon pricing in their NDCs are not included as different interpretations of the NDC text are possible. The carbon pricing initiatives have been classified in ETSs and carbon taxes according to how they operate technically. ETS does not only refer to cap-and-trade systems, but also baseline-and-credit systems such as in British Columbia and baseline-and-offset systems such as in Australia. Carbon pricing has evolved over the years and initiatives do not necessarily follow the two categories in a strict sense. Due to the dynamic approach to continuously improve data quality, changes to the map do not only reflect new developments, but also corrections following new information from official government sources. (Carbon Pricing Dashboard, The World Bank, 2020)

Figure 6: Prices in implemented carbon pricing initiatives



Source: (World Bank, 2020)

Figure 7: Overview of EU-27 progress towards the SDGs over the past 5 years, 2020 (Data mainly refer to 2013-2018 or 2014-2019)



Source: (Eurostat, 2020)

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