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Carbon Tax, a multilateral approach

-Master Thesis-

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Summary and keywords

This paper aims to analyze the efficiency of carbon tax in a multilateral context, and to this end, seek the principles and main characteristics that it should meet to achieve a substantial reduction in CO_2 emissions. A conceptual framework is also made, starting from the basics of the greenhouse effect to the impacts of the climate change, highlighting the anthropomorphic action and the need for response. Finally, the design of the carbon tax is presented together with the idea of multilateralism.

Keywords:
- CO_2
-Greenhouse Emissions
-Carbon Tax
-Mitigation
-Multilateralism

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Abbreviations

CAMS - COPERNICUS ATMOSPHERE MONITORING SERVICE

CBDR-RC - COMMON BUT DIFFERENTIATED RESPONSIBILITIES

CFC-11 - CHLOROFLUOROCARBONS

CFCs - CHLOROFLUOROCARBONS

CH4 - METHANE

CO_2 - CARBON DIOXIDE

COP – CONFERENCE OF THE PARTIES

CSIC - *CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS* - SPANISH NATIONAL RESEARCH COUNCIL

DCO - DEEP CARBON OBSERVATORY

ECMW - EUROPEAN CENTER FOR MEDIUM-RANGE WEATHER FORECASTS

EEA - EUROPEAN ENVIRONMENT AGENCY

EU – EUROPEAN UNION

EU ETS - EUROPEAN UNION'S EMISSION TRADING SYSTEM

FAO - FOOD AND AGRICULTURE ORGANIZATION

G20 - GROUP OF TWENTY

GDP – GROSS DOMESTIC PRODUCT

GHG – GREENHOUSE GASES

H20 - WATER, OXIDANE

HFC - HYDROFLUOROCARBON

IEA - INTERNATIONAL ENERGY AGENCY

ILO – INTERNATIONAL LABOUR ORGANIZATION

IMF – INTERNATIONAL MONETARY FUND

IPCC - INTERGOVERNMENTAL PANEL ON CLIMATE CHANG

MRV - MEASUREMENT, REPORTING AND VERIFICATION

N20 - NITROUS OXIDE

NAP - NATIONAL ALLOCATION PLANS

OECD - ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

OXFAM - OXFORD COMMITTEE FOR FAMINE RELIEF

PFC - PERFLUOROCARBON

PPM/PPB/PPT - PARTS PER MILLION/PARTS PER BILLION/PARTS PER TRILLION

RGGI - REGIONAL GREENHOUSE GAS INITIATIVE

SEM - SINGLE ELECTRICITY MARKET

SF6 - SULFUR HEXAFLUORIDE

UNEP - UNITED NATIONS ENVIRONMENT PROGRAMME

UN – UNITED NATIONS

UNFCC - UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

USA – UNITED STATES OF AMERICA

WB – WORLD BANK

WCI - WESTERN CLIMATE INITIATIVE

Introduction

The serious effects of climate change are getting harder to ignore every day that passes us, and the challenge of overcoming it needs to be met head on. Nowadays, numerous debates about which is the best method of action to deal with the problem arise, and the use of different mitigation tools have been the subject of analysis and studies for years. However, the current situation of the fight against COVID-19 has distanced these debates. António Guterres,[1] the Secretary-General of the United Nations, highlighted the urgency of climate change and the importance of not being minimized at the launch of the UN's assessment of the global climate in 2019. The Secretary-General also stressed that the virus will have a temporary impact a priori, considering that the climate emergency is a long-term issue, and asked not to overestimate the reduction in emissions that, according to some studies, is being seen as a consequence of COVID-19, linked to the reduced industrial activity in places like China and the reduction of air traffic on a global scale.[2]

Leaving aside the current situation, in reality, with the disparity of measures applied by various jurisdictions unilaterally and regionally, and after the lack of ambition of the 25th Climate Summit, recently held in Madrid, the need for a common economic mitigation tool has been placed on the agenda. In this context, carbon tax stands as the most efficient economic instrument. Not only because the fiscal structure that is necessary for its application is already established in most jurisdictions, but also because it constitutes an incentive tool for the use of alternative energy sources and work methodologies that generate less greenhouse gases emissions.

This work intends to analyze the carbon tax in a multilateral framework through desk research, with the IPCC, WB and IMF reports as the main sources of information, focusing on the nature of the tax and the advantages of its multilateral use, in order to confirm the main hypothesis; carbon tax is the most efficient tool to mitigate climate change, and it needs to be established universally. It also aims to consider the possible alternatives that could become complementary policies and, on the other hand, transfer the effective unilateral systems to the multilateral level.

The monograph is divided into four chapters: Climate change: a conceptual framework, carbon tax, the multilateral approach and final conclusions.

The first chapter will deal with the important matters regarding climate change and the anthropomorphic action, providing data of the major indicators. The second chapter aims to analyze and design the desirable carbon tax, comparing it with other alternatives and using current unilateral examples. The third aims to state the advantages of the application of the economic tool in a universal multilateral treaty. Finally, the fourth chapter aims to make final conclusions about the carbon tax in a multilateral treaty according to what was presented in the paper.

[1] Ninth Secretary-General of the United Nations. He was also the Prime Minister of Portugal from 1995 to 2002 and Secretary-General of the Socialist Party from 1992 to 2002.

[2] UN News. (2020, March 10). *Flagship UN study shows accelerating climate change on land, sea and in the atmosphere.* Retrieved March 30, 2020, from https://news.un.org/en/story/2020/03/1059061

1. Climate change: a conceptual framework

"What I want is to have the whole society putting pressure on governments to understand they need to run faster. Because we are losing the race." These were the harsh words of Antonio Guterres in an interview[3] before the last UN Climate Action Summit, in which the UN Secretary General requested before the assistance to all leaders to arrive with concrete and realistic plans, to improve their nationally determined contributions by 2020, in order to reduce greenhouse gas emissions by 45% in the next decade and achieve zero net emissions by 2050.

1.1 Greenhouse effect

To reduce emissions it is necessary, first of all, to understand what these emissions entail in the so-called greenhouse effect. The greenhouse effect is a process in which the thermal radiation emitted by the planetary surface is absorbed by the atmospheric greenhouse gases (GHG) and is radiated in all directions. As part of this radiation is returned to the surface and the lower atmosphere, this results in an increase in the average surface temperature compared to what it would be in the absence of GHGs.[4] Solar radiation at frequencies of visible light passes mostly through the atmosphere to heat the planetary surface, subsequently emitting this energy at lower frequencies of infrared thermal radiation. The latter is absorbed by GHGs, which, in turn, re-radiates much of this energy to the surface and lower atmosphere. This mechanism is named after its analogy to the effect of solar radiation passing through glass heating a greenhouse, but the way heat is trapped in the atmosphere is fundamentally different from how a gardening greenhouse works; which reduces air currents, isolates hot air inside the room and prevents heat loss by convection, although the specific effect is somewhat more complicated.[5]

In the atmosphere, the maintenance of the balance between the reception of solar radiation and the emission of infrared radiation returns approximately the same energy to space that it receives from the Sun. This balancing action is called the Earth's energy balance and defines the planet's average temperature.[6]

Over a sufficiently long period, the climate system tends to reach an equilibrium where the incoming solar radiation in the atmosphere is compensated by the outgoing thermal radiation. Any alteration of this radiation balance, either due to natural causes or caused by the human being (anthropogenic), is called a radiative forcing and involves a change in equilibrium temperature.

Measurements from the last two decades indicate that the Earth is absorbing between 0.5 and 1 W / m2 more than what it emits into space.[7] This imbalance has most likely been caused by the increase in the concentration of greenhouse gases. As a result,

[3] Covering Climate Now. (2020, September 19). CCNow UNSG António Guterres Interview, (online video) Retrieved January 12, 2020 from: https://www.youtube.com/watch?v=fFnDIIvWmL4

[4] IPCC. (2014). *Annex II Glossary*. pp. 117-130. Retrieved January 12, 2020 from: https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_Annexes.pdf

[5] Silverstein, S. D. (1976, July 16). *Effect of Infrared Transparency on the Heat Transfer Through Windows: A Clarification of the Greenhouse Effect.* Science 193 (4249): pp. 229-231. Retrieved January 17, 2020 from: ISSN 0036-8075. PMID 17796153. doi:10.1126/science.193.4249.229

[6] AEC, ACOMET. (n.d). *Vocabulario climático para comunicadores y divulgación general*. Retrieved April 8, 2020 from: http://www.acomet-web.com/vocabulario_climatico.pdf

[7] Hansen, J., Sato, M., Kharecha, P., von Schuckmann, K. (2012, January). *Earth's Energy Imbalance*. Science Briefs. NASA. Retrieved January 17, 2020 from: https://www.giss.nasa.gov/research/briefs/hansen_16/

the climate system adjusts, causing the symptoms we associate with global warming like: surface temperature increases, ice cap reduction, and rises in sea level.[8]

Without this natural greenhouse effect, Earth's equilibrium temperature would be around -18°C.[9] However, the average temperature of the Earth's surface is around 14 ° C, a difference close to 33°C, which gives an idea of the magnitude of the effect.[10] The Earth's natural greenhouse effect makes life, as it is known, possible. However, human activities, mainly the burning of fossil fuels and deforestation, have intensified the natural phenomenon, catalyzing global warming.

1.1.1 Greenhouse gases

The dominant factor in radiative forcing of the climate in the industrial age is the increased concentration in the atmosphere of different greenhouse gases. Most of them occur naturally, but the increase in their concentration in the atmosphere during the last decades is due to human activities. Other greenhouse gases are solely the result of human activities. The contribution of each one to radiative forcing during a specific period of time is determined by the change in its atmospheric concentration during that period and the effectiveness of the gas to modify the radiative balance. The current concentration in the atmosphere of a greenhouse gas is the net result of its emissions and past removals from the atmosphere. The main, so-called, greenhouse gases responsible for the described effect, are:[11]

- Water vapor (H2O), the most present of the greenhouse gases in the atmosphere. It is by definition the natural greenhouse gas. The water content in the air depends on the temperature. With the increase of the temperatures, the content of water vapor in the atmosphere increases and as a consequence the effects of other greenhouse gases get worse.
- Carbon dioxide (CO_2), which is produced by burning fossil fuels such as coal or oil. Carbon dioxide is the cause of most of the greenhouse effect affected by industrial activity. In Amazonia and Southeast Asia, it is produced by burning massively tropical forests.
- Methane (CH4), the main sources of methane are the degraded organic material produced in livestock, rice cultivation, landfills, and in oil and gas farms.

[8] Hansen, J., Sato, M., Kharecha, P., von Schuckmann, K. (2012, January). *Earth's Energy Imbalance. Science Briefs*. NASA. Retrieved January 17, 2020 from: https://www.giss.nasa.gov/research/briefs/hansen_16/

[9] American Chemical Society. (n.d.). *Predicted Planetary Temperatures*. Retrieved January 17, 2020 from: https://www.acs.org/content/acs/en/climatescience/energybalance/predictedplanetarytemperatures.html

[10] Jones, P. D.; Harpham, C. (2013). *Estimation of the absolute surface air temperature of the Earth.* Journal of Geophysical Research: Atmospheres 118 (8): 3213-3217. Retrieved January 18, 2020 from: ISSN 2169-8996. doi:10.1002/jgrd.50359

[11] IPCC. Solomon, S., D., Qin, M., Manning, R.B., Alley, T., Berntsen, N.L., Bindoff, Z., Chen, A., Chidthaisong, J.M., Gregory, G.C., Hegerl, M., Heimann, B., Hewitson, B.J., Hoskins, F., Joos, J., Jouzel, V., Kattsov, U., Lohmann, T., Matsuno, M., Molina, N., Nicholls, J., Overpeck, G., Raga, V., Ramaswamy, J., Ren, M., Rusticucci, R., Somerville, T.F., Stocker, P., Whetton, R.A., Wood, D. Wratt. (2007). *Technical Summary. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Chang*e. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 21-24. Retrieved January 18, 2020 from: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-ts-1.pdf

- Nitrogen oxide (N2O), which is a colorless, slightly toxic gas with an anesthetic and dissociative effect. It is neither flammable nor explosive, but it supports combustion as actively as oxygen when it is presented in appropriate concentrations with anesthetics or flammable material. It is the third most important long-term greenhouse gas.
- Ozone (O3), is a very aggressive pollutant. However, naturally occurring ozone in the upper layers of the atmosphere is beneficial because it serves as a protective filter against solar ultraviolet rays.
- Fluorinated gases, which are mainly used as propellants and coolants. They have contributed to the destruction of the ozone layer and after several campaigns by environmental organizations their use has been reduced considerably since 1990.

Although all of them (except CFCs) are natural, while they already existed in the atmosphere before the appearance of humans, since the Industrial Revolution and mainly due to the intensive use of fossil fuels in industrial activities and transport, there have been significant increases in the amounts of nitrogen oxide and carbon dioxide released into the atmosphere, with the aggravating circumstance that other human activities, such as deforestation, have limited the regenerative capacity of the atmosphere to remove carbon dioxide.

The increase in greenhouse gas emissions is the main cause of climate change. Since the beginning of the Industrial Revolution in the 18th century, carbon dioxide levels have increased by roughly 40% and methane levels by 150%. Other GHG emitting gases did not exist at pre-industrial levels such as the CFCl compound, called CFC-11, a liquid that boils at temperatures close to ambient. CFC-11 was used to form holes in soft foam products, such as pillows, padded rugs, cushions and seats and fillers in cars, among others.

Greenhouse gases affected by human activities			
Description	CO_2	CH_4	N_2O
Preindustrial concentration	280 ppm[12]	700 ppb[13]	270 ppb
Concentration in 1998	365 ppm	1.745 ppb	314 ppb
Concentration in 2018	407,8 ppm	1 869 ppb	331,1 ppb
Permanence in the atmosphere	5-200 years	12 years	114 years

1-Table 1.1.1 Main Greenhouse gases affected by human activities levels and its permanence in the atmosphere. Elaborated with data from IPCC Special Report on Global Warming of 1.5 ºC [14] and from the World Meteorological Organization.[15]

[12] Parts per million (ppm) is a unit of measurement by which the concentration is measured. Determine a tolerance range. It refers to the number of units of a certain substance that exist for every million units of the set.

[13] Parts per billion (ppb) same as ppm, measures concentration, but for every billion units in the set.

[14] IPCC. Masson-Delmotte, V.P., Zhai, H.-O., Pörtner, D., Roberts, J., Skea, P.R., Shukla, A., Pirani, W., Moufouma-Okia, C., Péan, R., Pidcock, S., Connors, J.B.R., Matthews, Y., Chen, X., Zhou, M.I., Gomis, E., Lonnoy, T., Maycock, M., Tignor, T., Waterfield. (2018). *IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C.* Retrieved January 10, 2020 from: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

[15] WMO. (2019, December 2). *Greenhouse gas concentrations in atmosphere reach yet another high.* Retrieved January 11, 2020 from: https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-atmosphere-reach-yet-another-high

This gas, went from 0 to a concentration of 268 ppt[16] after the preindustrial period.[17]

1.1.2 Greenhouse gas sources

The increase in the concentration of gases from the pre-industrial level is due to an increase in activities that involve greenhouse gas emissions. There are different sources; agriculture, along with deforestation, is responsible for about a quarter of global greenhouse gas emissions due to human action according to a report of FAO,[18] which ensures that if crops are included, livestock, forestry and fishing, emissions have almost doubled in the last 50 years and may increase by another 30% by 2050. According also to the FAO's report, livestock causes 14.5% of all anthropogenic greenhouse gas emissions, including carbon dioxide, nitrogen oxide, methane, fluorinated gases, and ozone. Livestock accounts for about a quarter of the methane emissions that it releases through intestinal fermentation and putrefaction of excrement.

Another important source is the use and production of energy. Two-thirds of global greenhouse gas emissions are due to the way we produce and use energy, according to the International Energy Agency.[19] In relation to this, the current food system currently consumes 30% of the energy available worldwide. Of this percentage, FAO draws attention to the fact that 70% is spent during the transportation, processing, packaging, storage, and sale of food. The energy consumption of buildings must also be taken into account, since they have a high energy consumption and emit large amounts of greenhouse gases, mostly in the form of heat.

Last but not least, industry. The production of nitrogen-based industrial chemicals emits nitrous oxide. There are also four types of fluorinated gases that are developed specifically for industrial use: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride. According to EU data, manufacturing and construction industries are responsible for about 12% of emissions, while industrial processes are 7.2% and energy industries 31.7%.[20]

1.2 Global warming and the anthropomorphic action

The emission sources abovementioned keep growing. On May 11 of the last year atmospheric levels of carbon dioxide passed 415 parts per million (ppm) for the first time in all of human evolutionary history. The measurement of 415.26 ppm was made by one of the main global warming monitoring stations in the world, the Mauna Loa Observatory in Hawaii that belongs to the Scripps Institute of Oceanography in the United States.[21] The 415 ppm measurement indicates that we are still emitting carbon dioxide into the

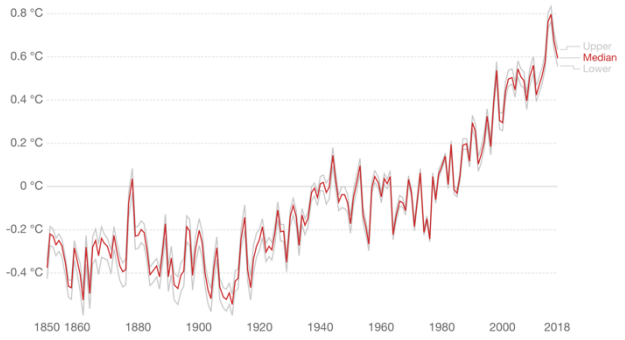
[16] Parts per trillion(ppt) same as ppm, measures concentration, but for every trillion units in the set.
[17] IPPC. Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (eds.). *IPCC, 2013: The Physical Science Basis.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 11-16 Retrieved February 25 , 2020 from: https://www.ipcc.ch/site/assets/uploads/2017/09/WG1AR5_Frontmatter_FINAL.pdf
[18] The Food and Agriculture Organization of the United Nations (FAO). (2015). *Estimación de emisiones de gases de efecto invernadero en la agricultura*. Retrieved January 19, 2020 from: http://www.fao.org/3/a-i6030s.pdf
[19] IEA. (2019). *The Critical Role of Buildings*. Retrieved February 25, 2020 from: https://www.iea.org/reports/the-critical-role-of-buildings
[20] EEA. (2019, December 17). *Greenhouse gas - data viewer.* Retrieved January 20 from: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer
[21] Martins, A. (1970, May 16). *Qué consecuencias tiene que hayamos superado el récord de CO2 en tres millones de años*. Retrieved January 17, 2020 from: https://www.bbc.com/mundo/noticias-48283274

atmosphere at the highest level that was considered possible 20 years ago. The fact that we reached 415 ppm when Earth's natural level has been 280 ppm for millions of years indicates the almost inconceivable way in which the planet has changed with the passage of humanity. This means that there was a significant increase of 50 ppm in two decades and we are increasing atmospheric concentrations at a rate of 3 ppm per year. At the moment it cannot be expected that CO_2 will stabilize at 415 ppm. Annual increases have been at one or two percent, with no forecast of decreases.

According to the last report of the scientists of the Deep Carbon Observatory (DCO),[22] the emissions of carbon dioxide carried out by mankind are up to 100 times higher than those caused by volcanic emissions in the last hundred years, which are often marked as having a major role in climate change and global warming. The report also states that the human being emits 36 gigatons[23] of C02 annually, to get an idea, a gigaton is equivalent to what three million Boeing 747s weigh.

The last UN climate action Summit comes at a time when there is a conviction that deadlines are running out to stabilize the atmospheric and climatic system and prevent the worst consequences of warming. The latest reports by the UN experts suggest that the current contributions announced by the countries are far from the objectives of the Paris Agreement.[24] The goal of the summit was to take action to reduce greenhouse gas emissions to prevent the global temperature from rising more than 1.5 degrees above the pre-industrial level, as global emissions are reaching unprecedented levels that seem to have not yet reached their peak. The problem is that in order for the planet to not heat more than 1.5°C, the CO_2 emissions must not exceed 450ppm.

It is estimated that human activities have caused approximately 1.0°C global warming[25] above pre-industrial levels, with an approximate range of 0.8° C to 1.2°C. Global warming is likely to reach 1.5°C if it continues increasing at this pace. There is a long-term warming-trend since pre-industrial period reflected in the observed global average surface temperature, settled in 0.87°C over 2006 and 2015 higher than over the 1850–1900 years. In the recent decades, global temperatures have risen drastically, to about 0.8 degrees more than our get-go of 1961-1990 [1-Graphic 1.1]. If we go back to 1850, we find out that temperatures were 0.4 degrees colder than in the period of 1961-1990. This data expresses, in general terms, the increase in temperature, but does not indicate the origin of this increase, or the reason for these changes.



2-Graphic 1.1 Median temperature anomaly from 1850-2018 average. Data from: Met Office Hadley Centre.

[22] Mckenzie, R.N., Hehe, J. (2019, October). *Earth's Outgassing and Climatic Transitions: The Slow Burn Towards Environmental "Catastrophes"?* Elements, (Vol. 15), n.05 pp. 325-330. Retrieved January 17, 2020 from: doi: 10.2138

[23] The equivalence of 1 gigaton is 10^9 tones. (1 ton = 1000 kg (= 10^6 g)).

[24] (French: *Accord de Paris)* is an agreement within the United Nations Framework Convention on Climate Change that establishes measures for the reduction of Greenhouse Gas (GHG) emissions, its applicability would be for the year 2020, when the validity of the Kyoto Protocol ends.

[25] Actual global warming level is equal to the average of a 30-year period with the center on 2017 assuming that the actual warming rates continue.

Some authors opposed to climate change, such a phenomenon provoked or accelerated by human action, argue that these variations are due to a behavior of the Earth outside the anthropomorphic action. Based on periods in which the Earth was heated and cooled, and therefore the warming from the Industrial Revolution would be natural variation that should not be cause for alarm. However, this time the change is faster and more extensive than any variation in the planet's climate in two millennia.

The global warming of the last decades has no parallel with events of previous climatic changes such as the so-called "Little Ice Age",[26] according to three new studies,[27] that analyzed evidence of prominent periods in Earth's climatic history over the past 2,000 years. Scientists have used tree rings to corroborate that, for centuries, temperatures dropped both on the European continent and in North America. But there is "no evidence confirming that there were uniform cold or warm periods worldwide in the last 2,000 years. The study's authors believe that the explanation is that regional climates in pre-industrial times were mainly influenced by random fluctuations within the climate systems themselves. External factors such as volcanic eruptions or solar activity were not intense enough to cause markedly hot or cold temperatures throughout the world for decades, or even centuries. The specialists have been basing their beliefs off of a database of the international research consortium PAGES (Past Global Changes[28]), which offers an overview of the climatic data of the last 2,000 years.

This time, global warming has occurred in more than 98 percent of the earth's surface, as detailed in the published studies above-mentioned, this shows that modern climate change cannot be explained by random fluctuations, but by CO_2emissions and other greenhouse gases. This boom in CO_2 emissions has a response; the human action, and there seems to be a consensus about it, since the effects are more evident every day. Awareness of what CO_2 emissions may entail, in terms of pollution, began to originate after the period of European industrialization, although, logically, with much less magnitude than current existing awareness.

The inhabitants of the most industrialized areas of the world, mainly in the United Kingdom, began to realize the impact that industries had on air and rivers. The most important phenomenon in this respect was what would later become a mythical theme of novels and films: the fog of London, which was nothing other than the effect caused by the massive burning of coal. The greatest impact took place in the so-called The Great Smog of London, which was a period of environmental pollution, between December 5th and 9th of 1952, which covered the city of London. The phenomenon was considered one of the worst environmental impacts to date, which was caused by the use of fossil fuels in industry and transport. It is believed that the phenomenon caused the death of 12,000 London inhabitants, and left another 100,000 sick.[29] The large number of deaths gave a significant boost to environmental movements and led to a reflection about air pollution, as the smoke had shown great lethal potential. Then new legal measures were taken, restricting the use of fossil fuels in the industry. In the following years, a series of legal

[26] The Little Ice Age (LIA) was a cold period that covered from the beginning of the 14th century until the middle of the 19th century. It ended an extraordinarily hot era called medieval climate optimum. The term was introduced by François E. Matthes in 1939

[27] Neukom, R., Barboza, L.A., Erb, M.P. (2019) Consistent multidecadal variability in global temperature reconstructions and simulations over the Common Era. Nat. Geosci. 12, 643–649 Retrieved December 19, 2019 from: doi:10.1038/s41561-019-0400-0

[28] The PAGES (Past Global Changes) is a project with the focus on the international efforts to coordinate and promote past global change research.

[29] Bates D. V. (2002). *A half century later: recollections of the London fog.* Environmental health perspectives, 110(12), A735. Retrieved November 24, 2019 from: https://doi.org/10.1289/ehp.110-a735

norms such as the Clean Air Act 1956 [30]and the Clean Air Act 1968[31], restricted air pollution. However, the first great pioneer who established a relationship between the burning of fossil fuels and warming was the Swedish scientist Svante Arrhenius [32]who already in 1896 formulated the hypothesis that a concentration of CO_2 gases would cause a temperature increase. Some of his hypotheses were not confirmed until 1987.

The issue was forgotten for a while until, around 1960, the American scientist Charles Keeling [33]began to measure the concentration of CO_2 in the atmosphere and, since 1980, it is shown that the temperature of the planet has increased. A decade later, strong evidence already existed of the warming induced by the gases emitted into the atmosphere, the phenomenon so called "greenhouse effect".

This awareness of the importance of human action as the head of this accelerated climate change has evolved until today, where the concrete weight of human action has already been stipulated with the criteria of various studies of some of the main organs of United Nations and other international organizations.

In addition, when analyzing the origin of these gases, the conclusion is that the responsibility for causing global warming is highly concentrated: by countries, four nations or economic zones (China, USA, EU and India) generate 60% of the emissions; by energy sources, 80% of them come from the use of coal and oil; and by sectors, industry and transport are responsible for 50% of the total, according to data from a recent Citigroup report.[34] In fact, Inger Andersen, executive director of the United Nations Environment Program (UNEP) makes it clear that:

> "The transformation must begin with the G20 negotiations, which account for 78% of total emissions, but 15 of the G20 members have not committed to a zero-emission objective."[35]

The report presented by UNEP shows that there is a gap between the commitments necessary to curb climate change and what each country said it could reduce. The report is very blunt with the big polluters, mostly developed countries, the figures speak for themselves: China is the country that emits most into the atmosphere with 10,065 million tons of CO_2 per year, followed by the United States (5,416), India (2,654), Russia (1,711), Japan (1,162), Germany (720) and Iran (720). Except for Germany, none of these countries has committed to the objective of carbon neutrality and in general, the emissions of all these large pollutants continued to grow in 2018, the last year of which there are reliable records pending the report of the of 2019. Among Latin American countries,

[30] The Clean Air Act 1956 was an Act of the Parliament of the United Kingdom that aimed to control domestic sources of smoke pollution by introducing smokeless areas.
[31] The Clean Air Act of 1968 was an Act of the Parliament of the United Kingdom that aimed to set the basic principle for the use of tall chimneys for industries burning coal, liquid or gaseous fuels.
[32] Arrhenius, S. (1896). *XXXI. On the influence of carbonic acid in the air upon the temperature of the ground*, The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, 41:251, 237-276. Retrieved November 24, 2019 from: DOI: 10.1080/14786449608620846
[33] Harris, D.C. (2010). *Charles David Keeling and the story of atmospheric CO2 measurements.* Analytical Chemistry 82 (19): 7865-70. PMID 20536268. Retrieved January 10, 2020 from: doi:10.1021/ac1001492.
[34] Citi Group. (n.d.). *Banking on 2030: Citi y los objetivos de desarrollo sostenible.* Available in: https://www.citigroup.com/citi/about/citizenship/download/Banking-on-2030-Citi-and-the-SDGs-Report_sp.pdf
[35] Stated that at the *Palais des Nations* in Geneva, Switzerland, November 26, 2019 at the launch of the Report on the Emission Gap of the United Nations Environment Program. UNEP. (2019, November 26). *Cut global emissions by 7.6 percent every year for next decade to meet 1.5°C Paris target - UN report.* Retrieved January 10, 2020 from: https://www.unenvironment.org/news-and-stories/press-release/cut-global-emissions-76-percent-every-year-next-decade-meet-15degc

Mexico is in the 12th place, with 477 million tons of CO_2 annually, and Brazil two places down with 457, meanwhile Spain is at number 24 with 268 million and Portugal at 56 with 51 million tons. These figures show the large amount of emissions that are produced, and how concentrated they are. This has a huge environmental impact, and unpredictable in terms of magnitude. However, to deduce the extent of climate change, we not only have to rely on current emissions, but analyze them together with atmospheric stock of CO_2 and other greenhouse gases, which reflects cumulative emissions up to that point. Thus, the contribution of a given country to global climate change can be measured in terms of its cumulative emissions, which has historically varied. Until 1990, the historical responsibility for climate change was attributable mainly to the most industrialized countries. Between the nineteenth and late twentieth centuries, the United States and Europe produced almost 75 percent of the cumulative CO_2 emissions. This generates a historical responsibility in terms of greenhouse gas accumulation, especially since the consequences generated by global warming should be understood as the result of this accumulation.

1.3 Impacts

This unprecedented global warming entails a series of direct and indirect effects both in the short term and long term. According to the IPCC Climate Report 2018[36], the last four years have been the hottest in history and Arctic winter temperatures have increased 3 ° C since 1990. Sea levels are rising, coral reefs are dying, and we are beginning to see the fatal impact of climate change in health through air pollution, heat waves, and food safety risks.

1.3.1 Environmental effects

The rise in temperatures is not only an impact per se, it is also one of the main causes of other impacts. The year 2019 was the second warmest year recorded after 2016, according to the analysis of the main international data collected by the World Meteorological Organization.[37] It also states that, on average, the annual global temperature in 2019 was 1.1 degrees Celsius more than the average of 1850-1900, which is used to represent pre-industrial conditions. Still, 2016 remains the warmest year recorded due to a very strong *El Niño,* an event of climatic origin related to the warming of the eastern equatorial Pacific, which caused an unusual rise in temperatures, and long-term climate change.

Following this increase in temperatures, another series of environmental consequences occurred, including deforestation and fires. The latter ends up causing the problem to be fed back, since according to the Carbon Global Atlas[38] report it indicates that CO_2 emissions related to fires, deforestation, and other changes in land use reached

[36] IPCC. Masson-Delmotte, V.P., Zhai, H.-O., Pörtner, D., Roberts, J., Skea, P.R., Shukla, A., Pirani, W., Moufouma-Okia, C., Péan, R., Pidcock, S., Connors, J.B.R., Matthews, Y., Chen, X., Zhou, M.I., Gomis, E., Lonnoy, T., Maycock, M., Tignor, T., Waterfield. (2018). *IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C.* Retrieved January 10, 2020 from: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

[37] The World Meteorological Organization is an international organization created in 1950 within the UN whose objective is to ensure and facilitate cooperation between national meteorological services, promote and unify measuring instruments and observation methods.

[38] The Global Carbon Atlas is a platform to explore and visualize the most up-to-date data on carbon fluxes resulting from human activities and natural processes.

6,000 million tons of carbon dioxide, which is about 800 million tons more than 2018 records. According to the report, the additional emissions come largely from the high level of fire and deforestation activity in the Amazon and in Indonesia. And this year, up to the date recorded on January 6, 2020, beginning in September 2019, Australian forest fires emitted 370 million tons of carbon dioxide, according to the Atmosphere Monitoring Service of the European Union ECMWF (CAMS).[39] The figure exceeds the total annual emissions of the 116 countries in the world with lower emissions.
Climate change does not cause forest fires directly. But the increase in the average temperature and the decrease in rainfall will create the ideal breeding ground for forest fires, especially in high mountain areas.

Climate change is also affecting essential processes of many organisms, such as growth, reproduction and survival of the first vital phases, and may compromise the viability of some populations. All these changes also cause a significant loss of biodiversity. However, the increase in temperature will make possible the proliferation of exotic species. When the climatic conditions of each place vary, many species from other latitudes are installed in different areas of our country according to their possibilities of adaptation to the new climatic parameters. Although is true that for many centuries the human being has transported species both intentionally and accidentally throughout the globe, with climate change, those who failed to survive in an inhospitable environment for their needs, are well adapted for multiplication. In the long run, this implies an impoverishment and homogenization of all the living beings on the planet. This is the case of the proliferation of species such as the jellyfish or the tiger mosquito against those that decrease, such as marine snails.

Other consequences that derive mainly from the increase in temperatures mentioned above is the melting of poles and the sea level rise. In the last 30 years, about three quarters of the volume of ice in the Arctic has been lost, which acts as a mirror bouncing solar heat. If we run out of sea ice, as well as freshwater,[40] the consequences could be irreversible. As the sun's rays penetrate deeper, the water will heat up, so evaporation from the sea will be faster and rainfall will increase. There would be changes in freshwater and marine currents, as well as weather modifications throughout the world. High temperatures, drought and the continuous acceleration of melting in the Arctic are causing deep concern among experts, who are seeing a terrible evolution in recent years linked to climate change. As a direct consequence, the level of the sea rises. According to the IPCC report abovementioned, during the twentieth century, this rise has been marked by an average of 15 centimeters, "but the current pace has more than doubled (3.6 mm per year) and continues to accelerate," the report shows. In addition to the rise of the sea, the loss of mass of the polar regions increases the expansion of warm waters in the oceans.

The rise on temperatures due to global warming causes also desertification. And must be distinguished from the phenomenon of drought, because sometimes it can lead to confusion. Drought is the reduction of water below the normal amount for a given period of time, desertification is a process of degradation of a fertile territory a direct consequence of human intervention and desertification is a natural process. In fact, today we can see the evidence that confirms this trend towards desertification. And this

[39] The Copernicus Atmosphere Monitoring Service (CAMS) is a service implemented by the European Center for Medium-Range Weather Forecasts (ECMWF).
[40] Lind, S., Ingvaldsen, R. B., Furevik T. (2018). *Arctic warming hotspot in the northern Barents Sea linked to declining sea-ice import.* Retrieved December 06, 2019 from: http://www.nature.com/articles/s41558-018-0205-y

phenomenon will bring consequences without return. For example, a study conducted by an international team with the participation of The Spanish National Research Council (CSIC in Spanish) has shown that the largest and tallest trees will be the most vulnerable to drought.[41] The droughts have also consequences themselves. In some regions, such as in the Horn of Africa, many populations have had to emigrate due to water scarcity. They are known as climate or environmental refugees. By 2100 many other regions of the planet could face episodes of extreme droughts.

Apart from the extreme droughts, according to the IPCC report cited above, climate changes give rise to increasingly extreme weather events, as climate balance is broken. More specifically, phenomena such as floods will increase by 50% due to the stagnation of the weather regulating atmospheric current, as a consequence of the Arctic warming. In the last 20 years, 12,000 extreme weather events have left their trail in virtually every corner of the planet. Torrential rains, hurricanes, floods, heat waves and droughts have claimed the lives of 495,000 people and have left in their wake a loss of 3.54 billion dollars, according to data from the Germanwatch Global Climate Risk Index.[42]

1.3.2 Economic and social impacts

These impacts will affect in different ways, on a greater or lesser scale, all areas of life, especially the economy, including future generations, and conditioning their way of life. Consequently, analyzing the impact on society is complex. It must be approached from many perspectives and showing different realities, since it will not have the same consequences for everyone.

Compared to current conditions, raising up to 1.5°C of global warming would pose greater risks to eradicate poverty, reduce inequalities and ensure human and ecosystem well-being. That limit is not considered “safe” for most nations, communities, ecosystems and sectors, and presents significant risks to natural and human systems compared to current warming of 1 ° C.

Impacts of 1.5°C would disproportionately affect disadvantaged and vulnerable populations through food insecurity, rising food prices, loss of income, loss of livelihood opportunities, adverse impacts to health and population displacements. Some of the worst impacts on sustainable development are expected to be felt among the livelihoods dependent on agriculture and the coast, indigenous peoples, children and the elderly, poor working people, poor urban dwellers from African cities, people and ecosystems in the Arctic and small island developing states.[43]

Because climate change is, above all, a social fact, because of its social causes and social consequences. It is not only an environmental problem, so it must be solved by society, by political, economic agents and citizens in general. The climate change is a challenge to the entire productive model known to date.

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[41] McIntyre, P. J., Thorne, J. H., Dolanc, C. R., Flint, A. L., Flint, L. E., Kelly, M., Ackerly, D. D. (2015). *Twentieth-century shifts in forest structure in California: Denser forests, smaller trees, and increased dominance of oaks.* Retrieved December 06, 2019 from: http: //www.pnas. org / content / 112/5/1458

[42] Eckstein, D., Winges, M., Künzel Vera, & Schäfer Laura. (2019). *Global Climate Risk Index 2020, Who Suffers Most from Extreme Weather Events? Wether-Related Loss Events in 2018 and 1999 to 2018*. Retrieved December 06, 2019 from: https://germanwatch.org/es/17307

[43] World Bank Group for the Social Dimensions of Climate Change workshop. Raleigh, C., Jordan, L., & Salehyan, I. (2008, March). *Assessing the impact of climate change on migration and conflict.*(pp. 5-6). Retrieved March 29, 2020.

1.4 Mitigation and adaptation to climate change

To reduce these impacts, there are two ways of acting: mitigation and adaptation. These two concepts, although are closely related to each other, have very different meanings. Mitigating climate change means avoiding and reducing greenhouse gas emissions into the atmosphere to prevent the planet from warming up in a more extreme way. In general, mitigation involves reducing greenhouse gas concentrations, either by reducing their sources or by increasing the ability of carbon sinks, which are natural or artificial deposits that absorb more carbon than they release, to absorb GHGs from the atmosphere.

To avoid a break in the 1.5/2°C target, CO_2 levels would have to be stabilized very quickly; this is generally unlikely, based on current policies so far. The importance of change is shown by the fact that global economic energy efficiency is currently improving at only half the rate of global economic growth.[44] The core of several propositions is the reduction of greenhouse gas emissions through the reduction of energy use and the change to cleaner methods of energy emission. Methods for energy conservation are frequently discussed, including increasing the energy efficiency of vehicles (hybrid vehicles, electric vehicles and traditional automobiles), or changing lifestyles and business practices. Alternative technologies are currently available including renewable energy (such as solar panels, tidal energy, geothermal energy, and wind energy) and, with more controversy, nuclear energy and the use of carbon sinks as well as granting credits for carbon emissions or fixing taxes on greenhouse gas emissions. The most radical proposals include the capture of carbon dioxide in the atmosphere and geoengineering techniques, carbon sequestration projects such as the capture of carbon dioxide in the air, even the management of solar radiation such as the creation of sulfuric aerosols in the stratosphere.[45] The growing global population and the growth of gross domestic product based on current technologies are counterproductive for most of these proposals.

For its part, adapting to climate change means altering our behavior, practices, systems and, in some cases, the way of life to protect people, the economy and the environment. The more we mitigate climate change right now, the easier it will be to adapt to changes that we can no longer avoid. This can be planned, either in reaction or anticipation of climate change, or spontaneous, that is, without government intervention. Planned adaptation is already taking place in a limited way. A concept related to adaptation is adaptive capacity, which is the ability of a system (human, natural or managed) to adjust to climate change (including climate variability and extremes), moderate potential damage, take advantage of opportunities or face the consequences.

Adaptation to climate change is especially important in developing countries as it is expected that they will be the most affected by the effects of climate change. Adaptation capacity is unevenly distributed in the different regions and populations, is closely related to social and economic development, and developing countries generally have less adaptive capacity. The challenge of adaptation grows with the magnitude and speed of climate change. A theoretical physiological limit to adaptation is that humans cannot

[44] Lowe, J. A., Huntingford, C., Raper, S. C. B., Jones, C. D., Liddicoat, S. K., Gohar, L. K. (2009). *How difficult is it to recover from dangerous levels of global warming?* Environmental Research Letters 4 014012. Retrieved January 17, 2020 from: Bibcode:2009ERL.4a4012L. doi:10.1088/1748-9326/4/1/014012.

[45] Leung, D. Y., Caramanna, G., & Maroto-Valer, M. M. (2014). *An overview of current status of carbon dioxide capture and storage technologies.* Renewable and Sustainable Energy Reviews. *39*, pp. 426-443. Retrieved January 16, 2020 from: https://www.sciencedirect.com/science/article/pii/S1364032114005450

survive average temperatures of more than 35°C.[46] Therefore, adaptability measures at this stage are inevitable and indispensable. But without mitigation measures, everyday adaptability measures will require more effort. That is why both must coexist, with the focus on the short term, but especially on the long term.

1.5 Normative evolution

Both mitigation and adaptability, to a greater or lesser extent, have appeared in the different international treaties regarding climate change. However, the multilateral agreements or treaties that address the problem, have a recent origin.

The foundation stone was laid with the United Nations Framework Convention on Climate Change (UNFCCC) , adopted in New York on May 9, 1992 and entered into force on March 21, 1994. Was founded with the aim of achieving the stabilization of concentrations of greenhouse gases in the atmosphere, at a level that prevents dangerous anthropogenic interference in the climate system and within a time frame sufficient to allow ecosystems to adapt naturally to climate change, and to ensure that food production is not threatened while allowing economic development to continue in a sustainable way.[47]

In 1988 the Intergovernmental Group on Climate Change (IPCC) was created. Two years later, this group published its first evaluation, based on studies by 400 scientists, where the international community was warned of a real problem that was changing the conditions of our planet. It pointed out the need to reduce GHG emissions by 60-80% compared to 1990 levels. Thanks to this body, governments implemented the United Nations Framework Convention on Climate Change, the starting point of the so-called Kyoto Protocol, an agreement by which in 1997 industrialized countries committed to reduce their GHG emissions.[48] The Kyoto Protocol entered into force in 2005, with the industrialized countries finally adopting a commitment to reduce greenhouse gas emissions by 5.2% by 2012 compared to 1990 levels. The least developed countries committed themselves, in principle, only to make an inventory of all your GHG emissions. The countries adhering to the Kyoto Protocol committed to achieving different objectives, in some cases of reduction (as in the case of Japan of 6%), in others of stabilization (as is the case of Russia) or of limited increase (Australia) . The EU, as a whole, promised to reduce emissions by 8% by 2012.[49]

The distribution among the EU Member States was based on criteria such as the GDP and the population of each Member State. The solidity of this pact was diminished due to the withdrawal of the United States from the signatory countries. The validity of the Kyoto Protocol ended in 2012, so since the 13th Conference of the Parties (COP 13) of the United Nations Framework Convention on Climate Change held in Bali in 2007, work has been done to reach an international agreement to fix a frame to replace it. Using

[46] Sherwood, C. S., Huber, M., Kerry, A. E. (2010). *An adaptability limit to climate change due to heat stress.* 107 No.21. PNAS. pp. 9552-9555. Retrieved January 02, 2020 from: doi:10.1073/pnas.0913352107.

[47] UNFCCC. (n.d.). *About the Secretariat.* Retrieved January 17, 2020, from: https://unfccc.int/about-us/about-the-secretariat

[48] Oberthür, S., & Ott, H. (1999). *The Kyoto Protocol: International climate policy for the 21st century*. Berlin: Springer. . Retrieved March 26, 2020

[49] UNFCCC. (n.d.). *Kyoto Protocol - Targets for the first commitment period.* Retrieved January 17, 2020 from: https://unfccc.int/process-and-meetings/the-kyoto-protocol/what-is-the-kyoto-protocol/kyoto-protocol-targets-for-the-first-commitment-period

the roadmap set in Bali, it was intensively negotiated for two years with the aim of reaching in December 2009, at the fifteenth (COP 15) held in Copenhagen, an ambitious international agreement to combat climate change. Despite the high expectations generated, the document that emerged from the high-level meeting did not receive a very positive evaluation, since it did not allow reaching a legally binding agreement to reduce emissions after the objectives set for 2012.

Another notable facet of the Copenhagen Accord was the fact that the political agreement was reached between key world leaders (the United States, China, India, Brazil and South Africa, especially the first two) with a decrease in the leadership of the European Union. However, countries did not legally commit to reduce their emissions or to combat climate change, being purely voluntary.[50]

After the Copenhagen Accord, several other meetings followed. The first was in Cancun in December 2010, where the intention was to reactivate the GHG emissions reduction pact. In 2011 the meeting took place in Durban, South Africa. The conclusions that were obtained then were more aimed at determining an action plan for the coming years, the commitment to extend the Kyoto Protocol, the creation of new negotiation platforms in order to determine regulations that promote concrete actions aimed at curbing Climate Change and the global review of the problem. Was signed, verifying scientific data with the intention of reaffirming the objectives not to exceed 2ºC and that collective action is the best way to achieve the desired objective.

In late 2012 in Doha, Qatar, COP18 was held. It was agreed to delay until 2015 the proposal for a timetable for the definitive creation of a global agreement on Climate Change, which would be launched in 2020. One year later, the Warsaw Climate Summit (COP 19 / CMP9) took place (November 11 and 23, 2013) among the results of this summit is a draft of the universal agreement that was worked on at the 2015 Paris Summit (COP21).

Between December 1 and 12, 2014, the Peru Summit (COP-20) took place in Lima with the aim of making a global provisional agreement to reduce greenhouse gas (GHG) emissions and that countries should seal in the Paris Agreement.

Finally, between November 30 and December 12, 2015, the Paris Climate Summit (COP 21) took place in Paris as well as the eleventh session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol. COP 21 ended with the adoption of the Paris Agreement, which establishes the global framework to combat climate change starting in 2020, promoting a transition towards a low-emission and climate-resilient economy. This Agreement establishes the objective of maintaining the world average temperature in this century "well below" 2ºC with respect to pre-industrial levels, committing itself to make all necessary efforts to limit this increase to 1.5ºC.[51]

Advances in international regulations that imply multilateralism are few. The vast majority of progress has occurred individually in certain countries, or in a smaller regional way among some countries. The most important multilateral agreements to date have shown shortcomings; firstly, the Kyoto protocol made it clear that the series of binding commitments that were adopted were insufficient. On the other hand, the Paris agreement established voluntary mitigation plans that were not imposed from outside, that is, each

[50] WWF. (n.d.). *Un paseo por las cumbres del clima más icónicas*. Retrieved April 04, 2020 from: https://www.wwf.es/nuestro_trabajo/clima_y_energia/cumbres_del_clima/

[51] Höhne, N., Kuramochi, T., Warnecke, C., Röser, F., Fekete, H., Hagemann, M., Day, T., Tewari, R., Kurdziel, M., Sterl, S., & Gonzales, S. (2017). *The Paris Agreement: resolving the inconsistency between global goals and national contributions.* Climate Policy, 17, pp. 16-32. Retrieved March 26, 2020 from: doi: 10.1080/14693062.2016.1218320

country set the goal of reducing emissions that considered appropriate. What in most cases ended up being insufficient.

1.6 Economics of global warming

In this context, the term "global warming economy" appeared. The global warming economy is a branch of the economy that studies the economic costs and benefits of global warming, as well as the economic impact of the actions established for mitigation or the adaptation (including geoengineering) of populations to global warming.

In the economic sphere, global warming is considered a negative externality caused by the emission of GHG. An externality is called a benefit or a cost that does not reflect its real market price. Negative externalities occur when the actions of an agent such as a company or the consumer, reduce the welfare of other agents in the economy, generating costs that are not offset by the market. From an economic point of view, global warming is a negative externality caused mainly by the production of energy with fossil fuels (oil or gas), an activity that generates GHGs, such as industry or transportation, as it is stated before. This externality has unique characteristics, one of the consequences of this singularity is that although we have been suffering with this externality for a long time, it has not been easy to recognize its existence, since assuming it implies attributing responsibilities and making decisions. Such externality crosses international boundaries. GHGs issued by any State today will spread around the world within a few days. That is, the emissions that occur in a specific State will affect people from other countries, even if they do not carry out activities that generate GHG. On the other hand, the impacts are long-term and permanent. GHGs will remain in the atmosphere for hundreds of years, so the pollution we generate today will affect the environment for centuries. Therefore, the effects can be immense and irreversible.

In the vast majority of externalities, increasing the level or quantity of the activities causing the externality increases the negative impacts proportionally. In the case of global warming there may be sudden events (known in economic terms as "non-marginal changes"). For example, if the Greenland ice sheet melts quickly, ocean levels can rise by several meters, if that happens there can be no rapid setback to the previous situation, then it could take thousands of years to return to "normal" levels of marine waters.[52] Thus, the cost to society of fossil fuel energy production, for example, is greater than the cost to its producers (the price of fossil fuels). The social cost includes both the private costs of energy producers and the costs of global warming. The world, as a whole, is harmed by the production of energy with fossil fuels (negative externality) since it generates the GHGs that in turn contribute to global warming.

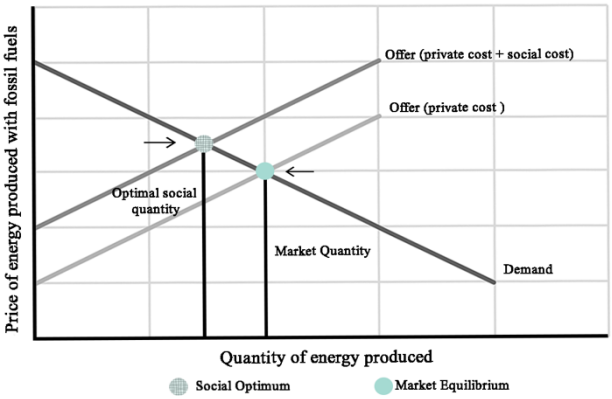
Negative externalities generate inefficiencies in the market as the market price does not include the cost of it as it only reflects private production costs. Then the market equilibrium point (private optimum) between private supply and private demand determines a lower energy price than it would have if we considered the negative externality of producing energy; the amount of equilibrium would be greater than what would be produced if we considered externality. To move from the private optimum to

[52] Watkiss, P., Downing, T., Handley, C., & Butterfield, R. (2005). *The impacts and costs of climate change. Brussels.* European Commission DG Environment. Retrieved March 29, 2020 from: https://www.researchgate.net/profile/RE_Butterfield/publication/277290614_Climate_Change_Policies_and_Measures'_ENVC220040088_The_Impacts_and_Costs_of_Climate_Change_Executive_Summary/links/55c48b4708aebc967df29698.pdf

the social optimum we should obtain a new supply curve called the social cost curve that is obtained by adding externality to the private cost.

1.7 Reach the Social Optimum

As shown in the elaborated demand [2-Graphic 1.4], the amount of energy produced at the market equilibrium point is greater than the social optimum that is obtained when all costs are considered. That is, the energy producer obtains a greater benefit without paying for all the costs incurred, the social costs are not borne by anyone, this is what is called a market error. If GHGs are an externality because those who generate them are imposing costs on others, then, as it is stated in this paper, the solution would be to "internalize" the costs created by the generation of such gases. In that case, issuing GHGs would become a cost of production for the producer. Therefore, there would be an incentive to reduce the generation of GHG: the more expensive it is to generate them, the greater the incentive to stop issuing them.



3-Graphic 1.4 Social optimum of the quantity of energy produced according to the production with fossil fuels price.

In the Global Warming Economy studies, some market mechanisms have been defined that can be used to reduce GHG emissions. These instruments are the financial incentives. They are commonly used subsidies for try to change the behavior of companies and consumers. Potential polluters will receive subsidies from the government if they adopt certain "clean" technologies or if they meet quantifiable emission reduction targets. For example, Aircraft companies, would benefit from the subsidies for changing their current engines for ones that are more environmentally friendly.

Moreover, fossil fuels are not inelastic,[53] if they were, establishing an incentive to reduce their use would not make sense, consequently the increase in price will lead to the search for substitutes such as ecological or alternative fuels as well as technologies that facilitate saving in fuel use. The current discussion focuses on how to introduce the cost of this externality in the most efficient way.

2. Carbon Tax

Over the last few years, the idea that economic instruments are the main method to combat climate change has crystallized. The final document of Rio + 20 "The future we want"[54] highlights the essential role of economic instruments to promote sustainable consumption and production, to mobilize capital investments and technology towards

[53] Goodwin, P., Dargay, J., Hanly, M. (2004). *Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review*. ESRC Transport Studies Unit, University College London, London, UK. Retrieved January 26, 2020 from: DOI: 10.1080/0144164042000181725

[54] UNCSD Secretariat. (2012, June 20-22). Rio 20: *the United Nations Conference on Sustainable Development, Rio de Janeiro, Brazil, 20-22 June 2012: the future we want.* New York. Retrieved January 04, 2020 from: https://sustainabledevelopment.un.org/content/documents/733FutureWeWant.pdf

sustainable activities and to provide adequate incentives while offering support for innovation. The way to deal with the climate crisis is one of the issues that raises the most debate among economists, climatologists, academics or other experts concerned about the impacts of global warming and its solutions. But taking into account the importance of economic instruments, within this wide range, are carbon taxes an effective method to counteract climate change?

One of the last winners of the Nobel Prize in Economics, William Nordhaus, has declared himself in favor of a tax that penalizes carbon dioxide emissions. "It's like paying taxes for the City Council to clean the streets, or for the State to eliminate the contamination of drinking water, or for the Armed Forces,"[55] he stated.

2.1 Why a carbon tax?

Carbon tax is within the most efficient economic instruments, that is, within those that introduce different incentives to be able to achieve more reduced emission levels, thereby altering the price system. The objective is to alter the price system to reduce or modify economic activities that may be harmful to the natural environment.

There is a general consensus among many economists that in order to reduce exponentially the expected effects of climate change, it is necessary to tax all parts of the production and use of fossil fuels.[56] A carbon tax can be an example of the application of the "double dividend hypothesis",[57] which means that the tax scheme encourages more efficient uses of existing resources and reduces the negative result of such uses. Thus, reducing the consumption of fossil fuels by making them more expensive, and encouraging the use of alternatives giving flexibility to internalize the cost of emission.

Currently, taking into account the global average, the prices of electricity, gasoline and other fuels poorly reflect the long-term costs of climate change or even the short-term health costs of burning fossil fuels. This "market failure" eliminates incentives to develop and deploy carbon reduction measures, such as energy efficiency (for example, high efficiency air conditioners), renewable energy (for example, solar panels), use of low fuel emissions (for example, biofuels from plants with high cellulose content) and behaviors that promote sustainable alternatives such as cycling. Taxing fuels will infuse these incentives throughout the production and consumption chain. From the purchase of household appliances from a private individual to the design of new products and capital investment of large companies. However, a carbon tax will not stop the global climatic disturbance by itself; other synergistic actions are also required, as the development of new clean technologies, but without a carbon tax the incentives to arise are scarce.

2.2 Basics and application of carbon tax

The Organization for Economic Cooperation and Development (OECD) defines carbon tax as “an instrument of environmental cost internalization. It is an excise tax[58] on

[55] Pardo, P. (2018, June 6). *Entrevista a William Nordhaus*. El País, pp. 22–23. Retrieved January 16, 2020
[56] Rabe, B. (Dec. 5, 2012). *The Political Viability of Carbon Taxation.* Brookings Inst. Retrieved February 20, 2020 from: http://www.brookings.edu/blogs/up-front/ posts/2012/12/05-carbon-tax-rabe.
[57] Fullerton, D., Metcalf, G. E. (1998). *Environmental Taxes and the Double-Dividend Hypothesis: Did You Really Expect Something for Nothing.* Pp: 221-225. Retrieved February 20, 2020 from: http://scholarship.kentlaw.iit.edu/cklawreview/vol73/iss1/6
[58] The Tax Policy Center defines the excise tax as a narrowly based tax on consumption, levied on specific goods, services, and activities. Definition available in: TPC. (n.d.). *What are the major federal excise taxes, and how much money do they raise?* Retrieved February 16, 2020, from:

the producers of raw fossil fuels based on the relative carbon content of those fuels."[59]

Based on the definition, it can be inferred the general idea that is that the fuel should be taxed based on the amount of carbon it contains. The amount of carbon in the fuel, together with the amount of this fuel that is used, determines how much carbon dioxide will be emitted into the atmosphere. Carbon-containing fuels differ in their content: coal is the fuel that contains the most carbon, followed by oil and natural gas. According to this, coal should be taxed more heavily than oil and this one, in turn, more than natural gas. Fuels that do not contain carbon, as nuclear energy and renewable energy sources would escape the tax and constitute relatively more economically attractive options.

This explains that the objective of the tax is not tax collection, but rather to discourage the use of fossil fuels by "internalizing" a negative externality generated by the emission of GHG.

2.2.1 Defining the taxable base

As the name suggests, what is going to be taxed are emissions of carbon dioxide. Carbon dioxide amounts to roughly 80% of the total greenhouse gas emissions (GHG) emitted globally, what makes it the main focus to face. True enough, there are jurisdictions that have introduced the taxation also of fluorinated greenhouse gases, the so-called f gases, the most common are perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs).[60] F gases are generally used for refrigeration systems, which implies that their emissions would not be related to the burning of fuels, and therefore, the tax design of these gases would have to be outside a system of taxing fuel products or actual emissions from the combustion of fuels and, therefore, deserves different considerations that are beyond the scope of this document.

A more difficult issue concerns the absolute magnitude of the tax. A broad tax base would generate a lot of controversy. However, the advantage is that a broader base would result in a lower tax rate in the long term, relaxing frontal opposition to the tax.

On the basis mentioned in the previous point that the fuel should be taxed based on the amount of carbon it contains and knowing that the emissions vary according to the type of fuel, we must establish the base of this tax. The highest tax should be imposed on coal and the lowest tax on gas. Non-fossil energy sources, such as hydroelectric and nuclear, among others, do not emit CO_2, so they would not be subject to this type of tax. However, these forms of energy have their own environmental costs, so, as a general economically efficient rule, all prices should reflect environmental and some social costs.

The most commonly used method of carbon tax in the different jurisdictions of the globe, tries to impose a tax on carbon to specific fossil fuels, mainly oil, gas and coal, and their derivative products. Hence the tax would apply at a point close to the extraction of fuel (at a mine or crude oil extraction site) or on importation into the jurisdiction. However, most of the tax schemes currently applicable allow to some extent that the tax

https://www.taxpolicycenter.org/briefing-book/what-are-major-federal-excise-taxes-and-how-much-money-do-they-raise

[59] OECD Statistics Directorate. (n.d.). *Glossary of Statistical terms*. Retrieved January 20, 2020 from: https://stats.oecd.org/glossary/detail.asp?ID=287

[60] Both Norway and Denmark tax carbon dioxide and f gas emissions. On the other hand, Spain only taxes gas f.

owed on the extraction or import is suspended during part of the distribution chain, if the fuels are handled by approved bodies.[61]

A general tax rate should be calculated and established, based on the average fossil carbon content of fuels, not on actual emissions produced by consumption or taking into account emissions that occur during fuel production. However, it should be noted that in the case of fuel combustion there is a sufficiently close relationship between carbon content and carbon dioxide emissions. Some jurisdictions have chosen to limit the scope to only certain fuels or cover only consumption in certain sectors. Iceland, for example, only applies taxes on gasoline, diesel and heating oil, while in India and the Philippines, only coal is taxed.

Within the framework of the European Union, seven states have introduced in their respective state a carbon tax covering all motor fuels, coal and most of the commercially available liquid and gaseous fuels used for heating. In these cases, the carbon tax has been added to an existing general excise tax scheme, as part of the general excise tax or as a separate tax. For these States, like the rest of the members of the European Union, there is a harmonized fiscal framework for the taxation of fuels,[62] which the EU Member States are obliged to follow in their national tax application. This implies that the seven EU Member States that have chosen to introduce a specific carbon tax are using the fuel tax base of this EU directive.

The current EU framework does not require Member States to impose a carbon tax, but if a Member State decides to introduce such a tax, it is considered as a right covered by the harmonized EU tax framework.[63] These EU-member states that have introduced a carbon tax have generally added it to an existing general special tax (sometimes called an energy tax), either as part of the general special tax (for example, in France) or as a separate tax (for example, in some Nordic countries). This same method could be applied in other states that are not part of the EU. There is an administrative advantage to base carbon taxes on fuel, since it allows the general fuel tax system to be used. Such systems already exist in some form in many jurisdictions. The name of this instrument may vary between jurisdictions: taxes, excise taxes or levies are the most common. An ambitious application of the tax should occur in the main fossil fuels, oil, gas and coal, and their derivative products.

2.2.3 Tax rate

In order to be effective, the carbon tax must meet economic efficiency conditions. However, determining the tax rate poses a great difficulty in the calculation of impacts and their transfer to marginal costs. The ideal tax rate would be that under the quality of the benefits resulting from the reduction of the last ton of carbon (marginal benefit) equal the additional cost resulting from the reduction of that ton (marginal cost). However, this tax rate could only be achieved in the long term.

[61] Carbon Tax Center. (n.d.). *Where Carbon Is Taxed*. Available in: https://www.carbontax.org/where-carbon-is-taxed/

[62] Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity, Retrieved February 20, 2020 from: https://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:283:0051:0070:EN:PDF. Products to be taxed are listed in Article 2 of the directive

[63] Article 4.2 of Directive 2003/96/EC.

The IMF quantifies that a tax of USD 35 per ton of CO_2 emitted in 2030 would generally coal, electricity and gasoline more expensive by 100%, 25% and 10%, respectively.[64]

Carbon taxes are also a clear incentive to redirect energy investment towards low carbon technologies, such as power plants that use renewable sources. A carbon tax of USD 35 per ton per se would exceed the level necessary to reach mitigation voluntary commitments from countries such as China, India and South Africa, and would be an adequate level for Indonesia, Pakistan, the United Kingdom and Islamic Republic of Iran to fulfill their ones. But not even a tax of USD 70 per ton would be sufficient in countries like Australia and Canada.

These conclusions reflect differences not only in the rigor of the commitments, but also in the sensitivity of tax emissions, which is higher in countries that consume a lot of coal, such as China, Indonesia and South Africa. However, beyond the commitments made by the different States, the IMF states that in order to limit global warming to 2°C[65] the limit considered safe, large emitting countries must take ambitious measures. For example, they should introduce a set of carbon taxes that increases rapidly to $ 75 per ton of CO_2 emitted in 2030. This would mean that household electricity bills would increase on average and cumulatively by 43% over the next decade, more in countries that still rely heavily on coal for electricity generation. Gasoline would cost 14% more. However, the income from this tax, between 0.5% and 4.5% of GDP (depending on the country), could be used to reduce other levies, such as income or payroll taxes that harm incentives for labor and investment, suggests the Fund.

Governments could also use the money raised to support employees and communities affected disproportionately by this adjustment, such as coal mines. The IMF also raises the possible payment of an equal dividend to the entire population. The Department of Fiscal Affairs of the Fund estimates that, as of today, about 50 countries have in some way or another a scheme that rates carbon emissions. However, the average world price for these emissions is currently only two dollars (1.82 euros) per ton, well below what the planet needs.

Vitor Gaspar, Paolo Mauro, Ian Parry and Catherine Pattillo, members of the IMF's Fiscal Affairs Department, point to Sweden as the example to follow.[66] With a carbon tax of $ 127 (115.7 euros) per ton, the country has reduced emissions by 25% since 1995 while the economy has expanded by 75% since then. In this way, the IMF recommends a minimum price for carbon emissions of 50 dollars (45.5 euros) per ton of CO_2 in the case of advanced economies and 25 dollars (22.7 euros) per ton of CO_2 in the case of the emerging ones in 2030. Doing so, the authors state that, would reduce emissions by 100 percent more than the countries' current voluntary commitments in the Paris Agreement on Climate Change 2015, although these commitments are far from limiting global warming to a value of 1.5°C or even 2°C.

Following this fuel approach, that uses the carbon content of fuels as the tax base, the tax rates should be expressed by volumes or weight units (such as liter of petrol or ton of coal) this constitute standard trade units what would lead to an effective and simplified

[64] IMF. (2019, December). *La economía del clima*. Finanzas y Desarrollo, 56(4), 6–12. Retrieved December 10, 2019 from: https://www.imf.org/external/Pubs/FT/fandd/spa/2019/12/pdf/fd1219s.pdf

[65] The last IPCC report states that the avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C. However, 2°C would be in the safe limit.

[66] Gaspar, V., Mauro, P., & Pattillo, C. Parry, I. (2019, October 11). *Fiscal Policies to Curb Climate Change*. Retrieved February 22, 2020 from: https://blogs.imf.org/2019/10/10/fiscal-policies-to-curb-climate-change/

tax administration.[67]

The Committee of Experts on International Cooperation in Tax Matters following the example of Sweden in 2018, they established that the formulation to calculate the tax according to the fuel content should be as follows:[68]

Carbon content [kg /unit] / $0{,}27^{7}$ = Emission of CO_2 [kg/unit]. Emission of CO_2 [kg/unit] * general CO_2 tax level [currency/kg fossil CO_2] = Tax rate [currency/unit].

The carbon content of the fuel is divided with the proportion of carbon in the carbon dioxide (0.27) to obtain the fuel emission factor. The latter is multiplied with the general tax level, expressed in terms of currency per kilo of fossil carbon. Therefore, the tax rate is expressed as currency per unit.

2.2.4 Progressive nature

Determining whether carbon tax has a progressive nature or not is essential. However, the first thing to determine is the starting point. It has to be effective in order to not incur in excessively high or unnecessary premature costs (of transition or adjustment). Thus, the carbon tax must be effective from the moment it is put in place while adapting to the needs of the moment. It should not start from an excessively high rate, since there will be no time for markets and companies to adapt to new price changes or they would have to do so by incurring to excessive costs.

After establishing an efficient starting point, the tax should be progressive over time (not very distorting) that does not increase costs geometrically, but that changes over time as emission targets are implemented, what will increase the acceptance of the society and thus make it more successful.[69]

Tax rates should be adjusted to the new information on marginal costs and benefits. The natural thing is that we have more and better information as the science of climate change advances and new mitigating technologies are launched. The frequency with which we should change the tax rates is another key point. There would be little benefit derived from adjusting rates in the short term since most opportunities to reduce limitations are related to long-term investments, such as changes in the industrial structure. However, it can happen, although less likely, that the development and implementation of new energy efficient technologies is faster than expected, so that would facilitate the reduction of the tax or the reduction of the increase of this. The availability of new technologies that do not emit carbon is a prerequisite, but not a guarantee, to reduce carbon taxes at a reasonable cost. The reduction of emissions also depends on reducing the barriers that currently exist for the dissemination and transfer of technology, the mobilization of financial resources, support for developing countries, etc.

2.2.5 Possible exemptions

A broad carbon tax guarantees greater effectiveness and speed in reducing emissions. However, the different realities of each State must be taken into account, in

[67] This system also corresponds in general terms to the guidelines that countries follow when reporting carbon dioxide emissions to the UNFCCC (IPPC National Greenhouse Gas Inventories).

[68] UN, Committee of Experts on International Cooperation in Tax Matters. (2019). *Environmental tax issues (Draft).* New York. Retrieved February 22, 2020 from: https://www.un.org/esa/ffd/wp-content/uploads/2019/04/18STM_CRP4-Environmental-tax-issues.pdf

[69] Carattini, S., Kallbekken, S., & Orlov, A. (2019, January 16). *How to win public support for a global carbon tax.* Retrieved April 03, 2020 from: https://www.nature.com/articles/d41586-019-00124-x

order to establish, if necessary, exceptions to the application. These realities will differ between jurisdictions and the most appropriate coverage of the carbon tax will depend on a variety of factors, including, the jurisdiction's emission profile; the structure of the main sectors or other relevant fiscal policies.

To exemplify this, the Republic of Ireland has a carbon tax that includes kerosene, marked gas oil, liquid petroleum gas, fuel oil, and natural gas. Nevertheless, it presents exemptions; it does not apply to electricity, since the cost is already included under the Single Electricity Market (SEM). Similarly, natural gas users are exempt from the tax if they can prove they are using the gas to "generate electricity, for chemical reduction, or for electrolytic or metallurgical processes".[70]

Another example is found in the case of Finland. This case must be analyzed carefully to be aware of what the use of exceptions may imply. Finland was the first country in the 90s to introduce a carbon tax. At that time, few exceptions were foreseen and only in certain specific sectors, since then it has varied dramatically due to the opening of the Nordic electricity market. Other Nordic countries provided a larger list of exceptions, especially energy-intensive industries, which was an important disadvantage for Finnish companies, which were unable to compete. As a result, Finland placed a border tax on imported electricity. For this reason, exceptions must be made taking into account the impacts on multilateral scope, in order to avoid trade conflicts.

2.3 Who pays the price of a carbon tax?

Direct taxes are normally paid directly by an individual or business relating to for example real estate owned, or income gained by the individual or business. An indirect tax is levied on particular goods or services and normally collected by a producer or retailer, not the final consumer. The cost of the tax is passed on to the consumer as part of the purchase price of the good or service. A carbon tax is thus an indirect tax. However, being an indirect tax means that the producer or seller who pays the levy to the tax authority is passing the cost of the tax to the consumer as part of the purchase price of a good or service. There are basically two kinds of indirect taxes, sales taxes (or value-added taxes) and excise taxes which. This means that a carbon tax – whether levied on fuels by weight or volume or on actual emissions – is an indirect tax and more precisely an excise tax (or in some jurisdictions is labelled an excise duty), differentiated from a sales tax or value-added tax because this last one is an ad valorem tax and proportional to the price of the goods. Another difference is that an excise tax typically applies to a narrow range of products (such as alcohol or tobacco products or petroleum products).

Like other forms of carbon pricing, and in contrast to command and control regulation, carbon taxes allow emitters to choose how to reduce their emissions, thereby allowing them to choose lower mitigation options cost. Carbon taxes also require emitters to pay the cost of emissions mitigation (e.g., by investing in emission reduction technologies) and the remaining emissions (through the payment of taxes). This means that carbon taxes not only prevent further pressure on government budgets but can also be a source of income. Thus, a carbon tax differs from policies such as subsidies, where the government compensates emitters for emission reductions and those emitters do not pay for the remaining emissions, so that these costs are borne by society.

[70] Bord Gáis Energy. (2020). *Help & Questions – Home Gas – Carbon Tax.* Retrieved February 04, 2020 from: https://www.bordgaisenergy.ie/home/he

2.4 Impacts

As mentioned, there are some specific companies that face this tax to a greater or lesser extent, but the macroeconomic consequences that it entails, including the rise in fuel prices as reported in the aforementioned IMF report, are assumed by society as a whole.

The assumption of a new cost does not affect all companies equally. Sectors that operate in markets with higher added value and that do not base their competitiveness on costs but on the efficiency of resources or other more sophisticated product attributes, will be less affected.[71] On the other hand, in the sectors whose products are more homogeneous, the cost structure bases its activity decisively and its modification can have a significant negative impact. This is the case of products such as energy intensive commodities -cement, steel, oil, etc.- for which the increase in production costs associated with emissions can have a significant impact on the business.

Originally, the economic burden that carbon pricing instruments transfer to the market falls on producers - more substantially the greater the carbon footprint of their products - but this is transmitted throughout the value chain to the consumer via prices, on many occasions. This increase in the final value of products can have consequences, such as their substitution by complementary articles, change in the size of the sectors, the adjustment of production methods, a change in long-term investments and a negative impact on the population from the base of the pyramid, which has less purchasing power.

A process of transferring operating costs in a transparent way is very important and can only be completed if its characteristics and existing competition allow it. In the case of regulated sectors (e.g., energy), in which producers do not have the capacity to increase prices, the inherent costs of carbon are impossible to recover and this is one of the main challenges posed by carbon pricing.[72]

On the other hand, carbon tax policies can aggravate the situation of vulnerable and low-income segments of society. The damage caused by climate change seems to fall more heavily on poor countries, which are often more affected by these effects, have less capacity to reduce them and have a larger population in areas that suffer from local pollution from the burning of fossil fuels. Moreover, in the transition period, when fossil fuels dominate energy and transportation systems and clean technologies are more expensive, higher carbon prices can translate into higher energy costs. These higher costs may fall disproportionately on either low-income or high-income households, depending on what percentage of their budgets they allocate to different energy services.

New evidence gathered from the experience of 21 OECD countries indicates that the distributive effects of pricing policies vary according to the fuel in question: taxes on transport fuels are not, on average, regressive in OECD countries, while those taxing fuels used to generate electricity and heating tend to be regressive, meaning that low-income households bear a proportionally higher tax burden compared to the wealthiest.[73]

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[71] World Bank. Kossoy, A., Peszko, G., Oppermann, K., Prytz, N., Klein, N., Block, K., Lam, L., Wong, L., Borkent, B. (2015, September). *State and Trends of Carbon Pricing.* Retrieved February 03, 2020 from: doi: 10.1596/ 978-1-4648-0725-1

[72] Gonne, N. (2010). *The Impact of a Carbon Tax on Sectors Competitiveness*, Working Papers 1015, University of Namur, Department of Economics. Retrieved March 25, 2020 from: https://www.unamur.be/eco/economie/recherche/wpseries/wp/1015.pdf

[73] World Bank, OECD. (2015, September). *Los principios Faster para lograr el éxito en la fijación de precio al carbono: Enfoque basado en las experiencias iniciales*. Retrieved February 03, 2020 from: https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/5d4c59607950650001ecc57f/1565284

These impacts need to be more fully understood, particularly in developing countries that depend on fossil fuels or non-renewable biomass derivatives. The final impact will depend on how the rate structure is established and the adjustments that can be made to benefit the poorest segments of the population.

In developing countries, household impacts may vary as a consequence of different patterns of fuel and electricity consumption. For example, rising kerosene prices, used for lighting and heating in low-income households without access to electricity, generally place a greater burden on the poorest. Carbon taxes can even slow down the shift in favor of modern cooking fuels, such as electricity or liquefied petroleum gas.

Gasoline generally shows a progressive pattern: the richest quintile tends to lose a greater proportion of its income than the poor. In almost all cases, increases in the price of electricity are slightly regressive, although there are some exceptions, such as India and other countries where many low-income households are not connected to the electricity grid.[74] Therefore, adverse effects such as inflation can be corrected if the income derived from the tax is used efficiently. In any case, the impacts today will always be less than those that will occur in the future if we continue with the same pattern of emissions and measures. According to a 2016 government report, each metric ton of carbon dioxide (CO_2) emitted now will cost tomorrow's economy between $ 12 and $ 120, and that cost will double by 2050.[75]And to this we must include the health costs caused by the contamination of hydrocarbons, which are estimated at $ 5 110 billion in terms of well-being. It has been calculated that, in the 15 countries with the highest greenhouse gas emissions, the health consequences of air pollution represent more than 4% of GDP.[76]

2.5 Revenues

The efficiently use of tax revenue could help to counteract the pernicious macroeconomic effects of rising energy costs. As it is stated above, the introduction of this tax increases the income of the State and the level of prices. When the objective is not an additional collection of taxes, but only the reduction of carbon emissions, a redistribution of the tax should be made without harming certain categories of population, such as rural populations that do not have public transport. According to the World Bank, carbon taxes can generate significant income. In many countries, even a modest tax of $ 30 per metric ton of carbon dioxide equivalent (t CO_2e) emissions could increase revenues by as much as 1-2% of Gross Domestic Product (GDP).[77] This indicates the

707828/FASTER+Principles+Spanish.pdf/t/5d4c59607950650001ecc57f/1565284707828/FASTER+Principles+Spanish.pdf

[74] IPCC. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, von Stechow, C. (2011) . *Fuentes de energía renovables y mitigación del cambio climático. Resumen para responsables de políticas y resumen técnico.* Retrieved February 20, 2020 from: https://www.ipcc.ch/site/assets/uploads/2018/03/srren_report_es-1.pdf

[75] The White House. (n.d.). *Technical Update of the Social Cost of Carbon for Regulatory Impact*. Analysis. Retrieved February 03, 2020 from: http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

[76] UN News. (2018, December 5). *Luchar contra el cambio climático beneficia la salud y el bolsillo.* Retrieved January 03, 2020 from: https://news.un.org/es/story/2018/12/1447141

[77] World Bank, Partnership for Market Readiness, PMR *(2017). Guía del Impuesto al Carbono: Un Manual para Creadores de Política.* Retrieved February 20, 2020 from: http://documents.banquemondiale.org/curated/fr/756281535607675797/pdf/129668-V3-WP-SPANISH-PUBLIC.pdf

magnitude of the economic impact of this tax, since it would mobilize large funds. That is why the use of these revenues must be carried out in the most efficient way possible, since the decisions will have profound implications in economic, tax and general welfare terms.

Generally speaking, governments can use three strategies to decide how to use carbon tax revenue: revenue neutrality, increased spending (included in debt reduction), and forego revenue by allowing entities to deliver offsets in place of tax payments. In practice, the lines between these three categories are not always robust and some approaches could be characterized by more than one strategy. Furthermore, there are alternative approaches within these three categories. Therefore, it is entirely possible to combine these approaches to suit local goals and context.

There are some examples of the combination of these approaches, Denmark is a good example to illustrate it. Danish carbon tax revenue has been used to reduce labor taxes, subsidize energy efficiency, and subsidize administrative costs for small businesses.[78] The first option is income neutrality which means that the government budget is essentially unaffected. Any carbon tax revenue is transferred directly or is offset by reductions in other taxes. Income neutrality is generally achieved through one of two approaches: household or business rebates. In its simplest form, income neutrality can be achieved by returning income to households and businesses through direct reimbursement. The latter can be offered equally to each taxpayer or targeted to specific groups such as low-income households. Home repayments are often progressive and potentially popular due to their high visibility. Refunds can also be provided to companies, for example to the ones exposed to international trade.

Income neutrality can also be achieved by using the income to reduce other taxes. Using carbon tax revenue to reduce other taxes often has the advantage of increasing the efficiency of the tax system, since carbon taxes generally have less inefficiencies and social costs than other taxes (for example, labor taxes, taxes capital and sales taxes). In this way the tax product is redistributed, the gain in purchasing power compensates for the increase in prices and the inflationary effect is limited. This approach is generally considered the most economically efficient way to use carbon tax revenue, although in some contexts increasing spending or reducing public debt also have significant economic advantages.[79]

The second option is to increase spending. Many jurisdictions have used part of the carbon tax revenue to support government initiatives and implement public policy. Often these are climate-related policies (for example, renewable energy subsidies or reverse auctions to reduce emissions), but sometimes governments also choose to fund non-climate change policies, including education, social programs and investment incentives. In many cases, revenues are carried over to the general budget of the state, to address different expenses without restrictions. In other cases, governments have broadly agreed on how new funds will be spent as a guide to government budget processes. Other jurisdictions that have opted for this method, for example, opt for more restricted allocations of these new revenues limiting them to specific uses. While this provides greater certainty that initial agreements on the use of revenue reached during the design

[78] Carl, J., Fedor, D. (2016). *Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world. Energy Policy*, *96*, 50-77. Retrieved February 20, 2020 from: https://reader.elsevier.com/reader/sd/pii/S0301421516302531?token=586D580C58564EF36C544D47B7C34564FB1D0625D90BF7880A8292FB81C2CE8BC8745CC99D10BE72E8C1FF2A1F8FEB68

[79] Kiuila, O., & Sleszynski, J. (2003). *Expected effects of the ecological tax reform for the Polish economy*. Ecological Economics, 46(1), pp. 103-120. Retrieved February 20, 2020 from: https://doi.org/10.1016/S0921-8009(03)00124-1

process will be honored over time, it can also result in inefficient allocation of resources.

Another method within this second option is debt reduction. Jurisdictions can also spend additional revenue on debt reduction. While this does not necessarily increase current spending, by paying off debt, the jurisdiction may reduce the burden of debt on future budgets.

Governments may also decide to forgo part of their income by allowing taxpayers to deliver offsets as a substitute for paying (or partially paying) their carbon tax obligations. When national offsets are used, this has the effect of redirecting government funds (tax revenue) or sectors covered by the tax to uncovered sectors (investment in emissions mitigation), although the amount of funds that will ultimately be invested in non-covered sectors will depend on a variety of factors, especially the price of offsets.[80] Offsets may help contain the costs experienced by responsible entities under the carbon tax and incentivize emission reductions outside the scope of the tax, but will lead to reduced revenues and potentially lower emission reductions in the sectors covered.

For this reason, the effective administration of the tax requires effective institutions and processes that implement the tax and apply compliance with tax obligations. Top-down taxes on direct emissions will also require the development of systems for accurate Measurement, Reporting and Verification **(**MRV)[81] of emissions.

Jurisdictions invariably already have a tax collection framework and revenue agency in place. To the extent possible, jurisdictions may also seek to align the administration of a carbon tax with existing frameworks and institutions. Carbon taxes that cover direct emissions and those that adopt additional design features, such as offsets, or linking exemptions or reimbursements to emission reduction agreements, may, however, require the development of additional capabilities.

For "pre-tax", emissions are generally calculated based on fuel sales, and avoid the need for specific MRV, while direct emissions-oriented taxes will generally need to establish more complex MRV systems. Where possible, jurisdictions may seek to build on existing systems, either those that already measure GHG emissions or those that monitor other relevant factors such as energy consumption or industrial production. Existing systems to ensure compliance with tax obligations, including audit procedures and penalties for non-payment, will also be used to apply to the carbon tax. At the same time, compliance can also be encouraged in the design of the tax itself, for example through simplicity and transparency, and by equating the design with the capabilities of the government.

The Regional Greenhouse Gas Initiative (RGGI) for the northeastern United States (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) is an example of applying a constructive approach to ease the burden of high electricity bills and making investments that take advantage of opportunities to increase energy efficiency and boost the economy with clean and renewable energy sources. Altogether, the RGGI has invested more than USD 1 billion of the funds raised through its emissions trading system in the energy future of the participating states of the New England and Atlantic area. The RGGI's investments in energy efficiency programs are expected to generate a total savings of more than USD 2.3 billion in the bills that the 1.2 million participating households will receive throughout

[80] Weisbach, D. A., & Metcalf, G. E. (2009). The Design of a Carbon Tax. *Reg-Markets Center Working Paper*, (09-05). Retrieved February 20, 2020 from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1327260

[81] OECD. (n.d.). *Measurement, Reporting and Verification (MRV) of greenhouse gas (GHG) mitigation.* Retrieved February 22, 2020, from: https://www.oecd.org/environment/measurementreportingandverificationofghgmitigation.htm

their lives. In addition, the RGGI provides direct assistance to help clients in need pay their energy and electricity bills. Between 2008 and 2012, the RGGI invested more than USD 130 million in energy efficiency measures and tariff subsidies in low-income sectors.[82]

2.6 Carbon tax vs alternatives

There are alternatives to carbon tax. However, none by itself, would achieve the effects estimated to be achieved by the carbon tax. These measures are really analyzed, since a priori constitute less controversial alternatives. As it is stated before in this paper, the short-term economic impacts are highly high, and depending on the tax rate that may be applied, they may be even higher. For this reason, despite being less ambitious, some of these alternatives must be taken into account.

2.6.1 Subsidies Reform

This measure seeks to dedicate state funds to support clean energy, using part of the state budget, in order to market it by reducing its price.
In this scenario, wind power, solar power and other renewable energy would occupy the position of fossil fuels in the energy market after obtaining an adequate and affordable price, for both producers and consumers, overcoming the initial obstacles to their commercialization.

This theory constitutes certain elements that are shared with the carbon tax, since with some of the revenues of the carbon tax, clean energies could be subsidized. However, global energy demand continues to seem unlimited and, in the absence of solid carbon emission prices, energy demand will exceed the potential of solar and wind energy systems, despite the studies that support that the establishment of all economically feasible energy efficiency measures could stabilize the actual emission levels up by 2040, despite the growth in global economic activity.[83]

In addition to not discouraging the use of polluting energy, there is no extra tax collection, so these budgets for clean energy come from other budget items. That is, the environmental damage could continue, and could cause losses in economic terms. Therefore, it can be inferred that this measure constitutes more a complementary measure than an alternative in itself.

2.6.2 Energy-Efficiency Standards

The Energy Efficiency Standards are the regulations that pursue energy efficiency. These measures since the 70s, have managed to save large amounts of electricity and fuel on appliances or vehicles that the market forces would not have achieved by themselves.[84] As in the case of subsidies reform, energy standards by themselves will never achieve the deep cuts in energy use necessary for the transition of clean energy. Setting standards takes a long time and invariably implies commitments to powerful industries such as the

[82] RGGI. (n.d.). *Program Review.* Retrieved February 20, 2020 from: https://www.rggi.org/program-overview-and-design/program-review
[83] Wooders, P. (2019, June 5). *Energy Efficiency and Subsidy Reform: A virtuous circle.* Retrieved February 05, 2020 from: https://www.iisd.org/gsi/subsidy-watch-blog/energy-efficiency-and-subsidy-reform-virtuous-circle-0
[84] Wiel, S., McMahon, J. E. (2003). Governments should implement energy-efficiency standards and labels—cautiously. Energy Policy, 31(13), pp. 1403-1415. Retrieved March 29, 2020.

automobile industry.

In addition, standards by nature can handle only one product or sector of use at a time and tend to be static, while energy use is constantly evolving, especially in dynamic and "disruptive" late capitalism. In addition, the standards offer no incentive for users (drivers, hosts) to change their behavior patterns to maximize energy savings.

Carbon taxes combined with efficiency standards will achieve much more than the standards alone, by encouraging manufacturers and builders to proactively maximize energy efficiency while providing consumers with continued incentives to make profitable decisions that value efficiency in their purchases, trips, real state acquisitions or other long-term goods.

2.6.3 Emissions trading (cap and trade)

Unlike the previous two alternatives, this one also “puts a price on carbon” and provide incentives to reduce the use of high-carbon fuels. An emissions trading system is a market instrument designed to reduce greenhouse gas emissions. It is based on the principle of “cap and trade”. The government imposes a maximum limit or cap on the total emissions of one or more sectors of the economy. Companies in these sectors must have a permit for every ton of emissions they emit. They can receive or buy permits, and thus trade with other companies. This is the “trade” dimension of the “cap and trade”.

The government determines the maximum amount of emissions allowed in the emissions trading system - that is the “cap” dimension of the “cap and trade”. The cap must be determined beforehand and must be reduced over time. It must also be aligned with the goal of reducing emissions from the jurisdiction. This sends a long-term market signal so that companies can plan and invest accordingly. Once the ceiling is set, the government distributes tradable permits to companies. A permit represents a ton of GHG emissions. The government may decide to grant the permits for free (based on historical emissions or performance standards) or auction the permits. The method of assigning permits will also affect the way companies manage their emissions.[85]

At the end of each trading period (for example, one year), each company must submit sufficient permits to cover its total emissions. To achieve this, companies can choose between one or more of the following options:

- Reducing their emissions: for example, improving efficiency in the production processes or switching to a less carbon-intensive energy source.
- Buy additional permits; to those companies that reduced their emissions and have leftover permits.
- Using national or international offset credits: trading systems typically allow companies to cover part of their emissions using credits from emission reduction projects in sectors that are not regulated by the emissions trading system. The most common credits are those that come from renewable energy projects or forestry projects.

Within the EU was established the European Union's Emission Trading System (or EU ETS) ,the world's largest multilateral trading system for greenhouse gas emissions and a mainstay of climate policy for the EU.[86] Under this regime, each Member State has

[85] Keohane, N. (n.d.). *How cap and trade works.* Retrieved February 22, 2020 from: https://www.edf.org/climate/how-cap-and-trade-works

[86] European Commission. (2017, February 16). *EU System (EU ETS).* Retrieved February 25, 2020 from: https://ec.europa.eu/clima/policies/ets

a National Emission Rights Allocation Plan (or NAP) that specifies a basket of greenhouse gas emissions for individual power plants and other important point sources.[87] In view of the above, it seems a good alternative, but is it more effective?

Carbon tax has a number of advantages over the emissions trading system. The first, and possibly the strongest, is that carbon taxes lend predictability to energy prices. However, cap and trade systems aggravate price volatility. This would cause a reduction in energy efficiency as it would discourage investments in renewable energy. The second argument has to do with climate urgency. The cap and trade system needs to establish many parameters and details that would hinder a rapid application. The carbon tax in terms of pace in the application would be more efficient.

Another aspect to highlight is transparency, carbon tax is transparent and understandable, while the cap and trade system is not only more opaque, but also more subject to manipulation by the industries involved that can act as lobby and interfere, what would undermine the trust of society.

Last, the cap and trade discourage voluntary individual carbon reductions, as they cause a reduction in the prices of emission permits that undermine low carbon investments; while carbon taxes are free of this unwanted negative consequence.

2.7 Alternatives as complementary measures

In view of the above, most alternatives can serve as complementary measures, as carbon taxes will generally be part of a larger mix of climate, energy and fiscal policies. Understanding how these policies can complement, overlap, and offset each other will facilitate an effective policy design.

Successful carbon pricing policies are complemented by measures that support a further reduction in emissions over time. These include policies that drive innovation, the removal of institutional barriers, incentives for certain behaviors, the reallocation of public spending, and policies that encourage investment in low-emission infrastructure works and seek to avoid dependence on polluting investments. Many of these can complement carbon taxes, but ideally the policy mix will avoid unnecessary overlap and remove any neutralizing incentives.

The role the carbon tax is expected to play within the broader policy mix will also be a determining factor in its design. For example, various jurisdictions have adopted carbon taxes as their "flagship" climate policy, while others have used it to cover emissions not covered by other policies (such as emissions trading system), this generates a quite different design of the tax (in terms of the base of the tax, tax rate, etc.).

Carbon pricing should be the centerpiece of a package of measures designed to achieve emission reductions at the lowest possible cost. It is often necessary to implement complementary policies to drive reform in areas that do not respond sufficiently to price signals, or where markets do not send those signals to consumers or organizations.

Direct regulation can also contribute supporting market instruments in cases where institutional barriers are observed (such as the lack of incentives for research and development), market deficiencies, difficulties linked to behaviors, inherited infrastructure that it ties economies to activities with high emission levels, or simply lack of financing. For example, in the absence of public transport infrastructure, it can be difficult to change the usual way in which people commute to their workplace even when the price of fuel increases. Compliance with these types of rules and regulations leads

[87] European Commission. (2017, February 16). National allocation plans. Retrieved February 25, 2020, from: https://ec.europa.eu/clima/policies/ets/pre2013/nap_en

consumers and producers to indirectly pay a price for reducing emissions.

Complementary policies are particularly important for achieving energy efficiency, as market failures, such as imperfect information and competing incentives, create hidden costs and risks that create adverse effects on otherwise efficient projects. When these obstacles are removed, households and small businesses become more sensitive to price signals.

Examples of measures to remove these barriers include providing information on benefits and ways to save energy, aligning homeowner and tenant incentives and boosting their ability and willingness to pay higher upfront costs (IPCC, 2014). Sometimes households and small businesses are willing to invest in low-carbon alternatives but do not have the financial means to do so or lack sufficient access to finance. Often, governments themselves put additional obstacles through counterproductive policies, such as energy price subsidies or fiscal rules that deprive entities that made investments of the benefits generated by their energy savings.

By aligning carbon pricing policies, the implementation of other policies is improved. Many countries have incorporated standards that contain performance metrics regarding emissions and energy consumption, such as those commonly applied to cars and buildings in China, the European Union and North America. Implementation on the ground is often flawed due to a lack of sufficient financial incentives for compliance. After applying the carbon price, buildings and cars with better energy performance may be less expensive than traditional alternatives, so that economic incentives are aligned with direct regulations.

2.8 Examples of successful carbon tax regimes

There are already more than forty countries that have adopted some form of pricing for the use of carbon,[88] either through direct taxes on fossil fuels or through limit programs and the exchange of emission rights. In the UK, carbon use plummeted after the introduction of the carbon tax in 2013. In the northeastern part of the United States, nine states have established a maximum level of emissions allowed to the energy sector and require companies to purchase permits of contamination that they can sell if they do not exceed the established limit. In the United Kingdom, greenhouse gas emissions have declined to their lowest level since 1890. Behind that decline appears the carbon tax as the main responsible, declining the use of coal of the electricity companies.

The UK is already technically covered by the European Union's emissions trading system (for the time being). But at the regional level, carbon prices have remained low and have had a very small effect on reducing emissions. In 2013, the British Parliament passed a minimum level of carbon prices for certain sectors (including electricity), a policy that essentially works as a carbon tax of approximately $ 25 per ton.[89] The tax has caused electricity companies to transit from coal to natural gas, which is relatively cleaner. This is perhaps the clearest example in the world of how a carbon tax generates a significant cut in emissions.

Moving to the two of the top polluters, in terms of emissions generated throughout history, a bleaker scenario is found. The US Congress is at a standstill for climate change

[88] World Bank. (2019). Map & Data. Retrieved February 17, 2020 from: https://carbonpricingdashboard.worldbank.org/map_data

[89] Plumer, B., Popovich, N. (2019, April 2). *These Countries Have Prices on Carbon. Are They Working?* Retrieved March 20, 2020 from:https://www.nytimes.com/interactive/2019/04/02/climate/pricing-carbon-emissions.html?mtrref=www.google.com&assetType=REGIWAL

deals, so efforts to set prices for carbon use have emerged at the state level. In the northeast of the country, nine entities participate in the Regional Greenhouse Gas Initiative,[90] an emissions rights trading system that auctions the few permits that exist for the use of that fuel at electric plants. The carbon prices of this system have been modest, and it is not clear how much the prices alone have reduced emissions in the American region. California, on the other side of the United States, has its own emissions trading program that goes beyond power plants; it also covers factories, refineries and other polluting industries. Likewise, prices have also remained at modest levels, partly because the initial maximum levels were quite high and because the lowest emissions at the state level so far occurred with other previous policies; among them, the required levels of efficiency for the operation of a building and the establishment of aggressive goals to increase the use of renewable energy.[91]

There are some signs that carbon pricing could be extended to more parts of the United States, but at the moment measures do not respond to pollution levels.
On the other face of the coin, since 2011, China has been experimenting with emissions cap and trading programs in pilot cities, including Shanghai and Shenzhen. The country plans to gradually undertake a program of maximum levels and emissions trading throughout the country; there would be several years of testing before expanding it to important sectors such as electricity, steel and concrete. If China succeeds, it will have created the world's largest carbon pricing program. However, the government has yet to fine-tune the key details, such as what the maximum level will be for overall carbon emissions.

2.8.1 The Canadian case

Canada has one of the most radical carbon pricing programs in the world. The government of the Prime Minister Justin Trudeau and the Liberal Party imposed a nationwide tax on oil, coal and gas, which this year is $ 20 per ton of carbon dioxide and in 2022 will reach $ 38 per ton. Most of the income will be reimbursed to Canadians in their tax returns; The government estimates that these reimbursements will offset the higher electricity costs for approximately 70 percent of the population.

Some key industries that face intense commercial competition, such as steel and the chemical industry, are exempt from Canada's tax. But they will participate in a program in which the most polluting companies within a sector have to buy carbon credits from the cleanest companies.[92] In total, both programs are expected to cover between 47 and 90 percent of the emissions in each province. Provinces can be excluded from the federal program if they design their own local climate policies. For example, British Columbia has had a higher carbon tax since 2008 than the national one - it increased to $ 30 per ton this year - and Quebec has an emission rights trading system. However, four provinces, including Ontario, refused to draw up their own plans, so the federal tax that came into effect on April 1 was established in those places.

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[90] RGGI. (n.d.). Program Review. Retrieved March 20, 2020 from: https://www.rggi.org/program-overview-and-design/program-review

[91] Ho, B., & Jackson Morris. (2017, July 19*). California Leads Off: Now RGGI Must Grab the Climate Baton.* Retrieved March 21, 2020 from: https://www.nrdc.org/experts/jackson-morris/california-leads-now-rggi-must-grab-climate-baton

[92] Government of Canada. (2020, April 8). *Climate Change Canada*. Retrieved February 25, 2020 from: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/putting-price-on-carbon-pollution/technical-briefing.html

This tax is fundamental in Trudeau's plan, in 2030 Canada's emissions are planned to be 30 percent lower than those of 2005. Moreover, Quebec, which together with British Columbia, Manitoba and Ontario are part of the Western Climate Initiative (WCI), linked their emission rights trading systems as of January 1, 2014. Together, they form the largest carbon market from North America. To date, four auctions have been organized (in November 2014 and in February, May and August 2015). The systems were designed to be able to link them, and before starting the linking process, they were evaluated to verify that they had the same degree of demand and to guarantee the environmental integrity of the scheme.

The case of Canada is a clear example of how to reduce carbon emissions while using the revenues effectively. The general idea is to create incentives for individuals, households and businesses to build on investments to lower their emissions.

Therefore, as stated above, the provinces and territories were given two years to implement their own carbon pollution pricing system that meets a series of criteria, if they did not want to use the national system.

The national system has two basic axes:

- The benchmark, basically is the commitment, including that of the federal government, to partially or totally implement a system of pricing carbon emissions in the provinces and territories that have requested it or in those that do not previously have this system that comply with the reference points.
- • Federal support, under the Greenhouse Gas Pollution Pricing Act, adopted on June 21, 2018, the "endorsement" has two parts:

  1. Regulatory charge on fuel: applied from April 2019 in the secondary provinces.

  2. Regulatory system for large industry (called Results Based Pricing System or OBPS):[93] applied since January 2019 in the secondary provinces.

On the other hand, Canada serves as an example of how to use emissions tax revenue. Canada has a so-called Climate Action Incentive Payments. Individuals and families can claim the Climate Action Incentive bill at the time they file their tax returns earlier in the year and receive it as part of their tax assessment. The amount to be received varies according to various factors depending on the province in which the claimant's tax domicile is located.

These factors are mainly the annual income from the fuel tax in said province and the size of the family nucleus. In addition, residents of small and rural communities receive an extra supplement of 10%. The average middle-class family is estimated to receive more payments than the costs incurred as a result of carbon pollution prices. All income is audited and reported annually to ensure the neutrality of the income and that it is returned to the jurisdiction of origin.

[93] Government of Canada. (2020, April 8*). Output-Based Pricing System*. Retrieved February 25, 2020 from: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system.html

Both Table 4 and Table 5 collect data and estimates regarding this emission tax in the provinces of Ontario, New Brunswick, Manitoba and Saskatchewan. The first is an estimate of the average cost impact for each family unit. As the carbon tax also increases, the impact increases to a greater or lesser extent in each province. The other table shows an approximation of the average impact of the Action Incentive Payment per family nucleus. Both means indicate that the return is greater than the payment, which indicates that the average family nucleus is not harmed by the measure adopted. In addition, the government will allocate part of the collections for different purposes. Money will go to hospitals, schools, universities, municipalities and indigenous communities.

Average cost impact per household[94] of the federal system

PROVINCE	2019	2020	2021	2022
ONTARIO	$244	$357	$463	$564
NEW BRUNSWICK	$202	$296	$386	$470
MANITOBA	$232	$342	$447	$547
SASKATCHEWAN	$403	$588	$768	$946

4-Table 2.8.1. Average cost impact per household[1] of the federal system in 4 provinces. Elaborated with data from Canadian government website.

As with costs and incentives, there will be a progressive increase in the amount allocated. On the aforementioned Canadian government website, estimates in Ontario, for example, range from $50 million in 2019 to $100 million in 2022 for these purposes. In Manitoba, in the same period of time, the increase is from $5 to $15 million.

Average climate action incentive payment per household

PROVINCE	2019	2020	2021	2022
ONTARIO	$300	$439	$571	$697
NEW BRUNSWICK	$248	$365	$476	$583
MANITOBA	$336	$495	$649	$797
SASKATCHEWAN	$598	$883	$1,161	$1,419

5-Table 2.8.1 Average climate action incentive payment per household in 4 provinces. Elaborated with data from Canadian government website.

Another fund to which part of the income collected will be allocated is the aid for small and medium-sized companies. Taking the example of Ontario, the funds allocated in 2019 were $105 million, with the expectation of reaching $205 in 2022. These funds for these companies facilitate the work of reducing emissions by investing in cleaner but more expensive technologies and thus reduce emissions efficiently.

[94] Average household of 2.6 people

3. The multilateral approach

The idea is clear, a global problem, a global solution. The different international regulations in this regard have turned out to be insufficient and sometimes they did not even establish mandatory regulations, but rather recommendations.

Since the entry into force of the United Nations Framework Convention on Climate Change in 1994, the member states of the United Nations have systematically participated in multilateral negotiations. In this context, and gradually, the policies and measures that should allow addressing the causes and facing the effects and impacts of climate change were defined and adopted, so that the adaptation of ecosystems and human societies was possible.

To this end, multilateral negotiations should be governed by the spirit, principles, criteria and commitments stipulated in said Convention and be guided by the best available scientific knowledge. The Intergovernmental Panel of Experts on Climate Change has been the accredited scientific body for this purpose and has played a crucial role, timely providing the multilateral process with the relevant information required for sustained decision-making. However, throughout the 20 years of the multilateral process, the negotiating strategies of the group of developed countries (according to UN terminology)[95] have focused on one hand, minimizing, evading and abandoning the commitments derived from the Convention; and on the other, in transferring them to the group of developing countries, or at least redistributing them among all parties.

In pursuit of their objectives, developed countries and their allies have manipulated and put the multilateral process on track in favor of the interests of sectors and groups of world economic power, and the electoral political interests of the governments that sponsor them.[96] This is in clear violation of the fundamental principles of the Convention, particularly with the principle of "common but differentiated responsibilities" (CBDR–RC).[97]

In order to provide it with universal status, despite the limited success of previous agreements, the treaty must be carried out within the framework of the United Nations and continue to be guided by the IPCC. But to make it work, the treaty must go beyond recommendations and set obligations, which is difficult, due to the lack of commitment found in previous agreements. The obligations must be based on the establishment of an equal carbon tax for all, in order to avoid the consequences that an unequal policy would have, as it is established in the following section. And through the revenues collected, it could correct the asymmetries, instead of treating them with different taxes for each State depending on the needs of each one.

3.1 The importance of multilateralism

In addition to giving a collective response to a collective problem, the multilateral option becomes a possibility to alleviate the main problems derived from the application

[95] United Nations Statistics Division. (n.d.). *Standard Country and Area Codes Classifications (M49): Developed Regions.* Archived from the original on 11 July 2017. Retrieved March 22, 2020 from: https://unstats.un.org/unsd/methodology/m49/

[96] Aguilar, Y., Illouz, E., Aronoff, K., Tooze, A., Stiglitz, J., Stefanoni, P., Baker, D. (2014, July 1). *Entre la laxitud y la "emergencia". Los consensos multilaterales sobre cambio climático: Nueva Sociedad.* Retrieved March 26, 2020 from: https://nuso.org/articulo/entre-la-laxitud-y-la-emergencia-los-consensos-multilaterales-sobre-cambio-climatico/

[97] UN. (n.d.). Declaración de Rio sobre el Medio Ambiente y el Desarrollo. Retrieved March 25, 2020, from https://www.un.org/spanish/esa/sustdev/agenda21/riodeclaration.htm

of different carbon tax in different jurisdictions in absence of a treaty that establishes common obligations and rights, as well as some specific ones, focusing in developing countries, and on the other hand, on countries that have historically contributed with more emissions.

3.1.1 Carbon leakage

One of the advantages of the multilateral carbon tax, is avoiding carbon leakage. Carbon leakage is defined as the reduction of carbon dioxide emissions in those countries that have signed emission reduction commitments, offset by an increase in emissions in countries where there is no such emission control.[98] Indeed, there is a risk of generating a "carbon leak" as a result of the unilateral application of a carbon tax, especially if it is in a small open economy country. This is because it increases the operating costs of the affected companies, which creates a competitive disadvantage and can lead to the substitution of imports for local production or even to the relocation of carbon-intensive production to countries with less strict regulations (or without any regulation). The problem is that the carbon footprint decreases in the country that implemented the policy but increases in the country with more lax regulations. Which would lead to a worse scenario. Global emissions are likely to increase in net terms, since importing implies greater emissions associated with international transport, and many times greater emissions during the production process due to less efficient technologies.

Peters and Hertwich distinguish two types: a "strong carbon leakage", which occurs when production moves from one country with a commitment to reduce emissions to another with less demanding environmental legislation, and a "weak carbon leakage", that is calculated taking into account the CO_2 incorporated in imports that countries, with stricter environmental regulations, make to countries without commitments to reduce emissions.[99] Therefore, both types of carbon leakage will occur as long as there are asymmetries in the adoption of climate policy due to a direct effect of said policy on the price of CO_2 and an indirect effect, caused by the increase in the price of electricity, which increase companies' production costs.[100]

Despite the fact that carbon leakage can occur through different channels, via competitiveness, via investment and via price of fossil fuels,[101] the most important channel and the one that is of greatest concern, especially at the political level, is competitiveness, since the departure of the affected companies would harm the economy,

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[98] IPCC. Pachauri, R.K, Reisinger, A. (2007). *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* pp. 104. Retrieved March 26, 2020 from: https://www.ipcc.ch/report/ar4/syr/

[99] Peters, G. and Hertwich, E. (2008): *CO_2 Embodied in International Trade with Implications for Global Climate Change,* Environmental Science & Technology, nº 42 (5), pp. 1401-1407. Retrieved March 26, 2020 from: https://pubs.acs.org/doi/10.1021/es072023k

[100] Sijm, J., Kuik, O., Patel, M., Oikonomou, V., Worrell, E., Lako, P., Annevelink, E., Nabuurs, G., Elbersen, H. (2004). *Spillovers of Climate Policy. An Assessment of the Incidence of Carbon Leakage and Induced Technological Change Due to CO2 Abatement Measures*. Netherlands Research Programme on Climate Change. Report 500036 002. Retrieved March 26, 2020 from: https://www.researchgate.net/publication/27451977_Spillovers_of_Climate_Policy_-_An_assessment_of_the_incidence_of_carbon_leakage_and_induced_technological_change_due_to_CO2_abatement_measures

[101] IEA & OECD. Reinaud, J. (2008): *Climate Policy and Carbon Leakage – Impacts of the European Emissions Trading Scheme on Aluminium, IEA* Information Paper, Paris. Retrieved March 29, 2020 from: https://www.ictsd.org/sites/default/files/downloads/2008/11/iea-paper-on-climate-policy-and-carbon-leakage-impacts-of-the-eu-ets-on-aluminium.pdf

mainly in terms of employment. Concern about the loss of competitiveness of the industry thus stands as one of the obstacles when it comes to establishing emission reduction targets of an international nature, since is probable that the implementation of an emissions reduction policy, which it does not affect the agents involved in international trade, it generates a carbon leakage problem for some sectors, mainly those more exposed to that trade and more intensive in greenhouse gas emissions.[102] The most affected industries are cement, chemicals, steel, paper, glass and food. In the end, if companies fail or move to another country, there would be no tax collection either. In other words, the tax would be ineffective both from a collection and an environmental point of view. Carbon leakage shows the need to coordinate nations, guaranteeing a global application.

3.1.2 Support for developing countries

The multilateralism and universality of the treaty also has another advantage, not leaving any state behind. Some countries have been more affected than others and, unfortunately, the most intense and negative effect is being borne by developing countries, which have not even been the most intensive users of fossil fuels and, therefore, historically have contributed less in GHG emission. The problem for these countries is even greater because they do not have enough resources to incur the enormous expense of mitigation or adaptation processes. In view of this inequality, the countries that are suffering an early affectation stage by global warming need to be compensated by the international community, but more specifically by the more developed countries, though aid in form of economic compensation and technical assistance to face the adaptation process.

One of the main achievements of the Kyoto Conference was to give an operational sense to the principle of "common but differentiated responsibility" mentioned above, which implies that developing countries have a role to play. Faced with this reality, and according to this principle, the countries that have historically produced and continue producing excess carbon dioxide per capita have a "carbon debt", and that countries that have hardly used carbon dumps and have instead conserved ecologically sensitive areas that contribute to climate balance, should be compensated. Especially, when there are distortions that deepen the inequity in the treatment of climate change, such as the total annual subsidy of developing countries to the industrialized ones for global carbon emissions that have made by producing their emissions.

Jyoti Parikh, who belonged to the United Nations International Panel on Climate Change, stated in 1995 that the average global emissions were approximately one ton of carbon per person per year. The industrialized countries produced ¾ of these emissions instead of ¼ which is what corresponded to them by their population. The difference was 50% of total emissions, approximately 3,000 million tons. If we look at the increased marginal cost of the reduction, the first billion tons could be reduced at a cost of about $ 15 per ton, but later this cost would increase much more. If we take $ 25 as the average price, then there would be a total annual subsidy of $ 75,000 million from the countries of the South to the countries of the North.[103]

Indeed, the Financing for Adaptation index developed by OXFAM, for example,

[102] Demailly, D. and Quirion, P. (2008): *European Emission Trading Scheme and Competitiveness: a Case Study on the Iron and Steel Industry*. Energy Economics, vol 30 (4), pp. 2009-2027. Retrieved March 29, 2020 from: https://www.sciencedirect.com/science/article/pii/S0140988307000230

[103] Parikh, J.K (1995), *Joint Implementation and the North and South Cooperation for Climate Change.* International Environmental Affairs, 7,I. pp 22-41. Retrieved April 03, 2020.

considers that 28 countries should be responsible for financing adaptation in developing countries. According to the study, the United States and the European Union should jointly contribute around 75% of the necessary funds (the US slightly more than 40% and the EU more than 30%). Japan, Canada, Australia and the Republic of Korea should contribute around 20% of the costs, with Japan having to assume half of this percentage.[104]

This confirms that the multilateral treaty must reflect this reality and, through tax revenues, make up for the deficiencies of developing states, which historically have contributed less to greenhouse gas emissions. This fact is reinforced if the treaty also contemplates the different socioeconomic realities of the different States. The informal economy plays an important role in developing countries, which would make difficult the application of an economic instrument such as carbon tax unilaterally without external support. According to the latest ILO report, it shows that 2 billion people are in informal employment, the vast majority in emerging and developing countries, representing more than 61% of the world's active population. If we analyze it by area and country, in Africa 85% of jobs are informal, in Asia, the Pacific and the Arab states the percentage rises to 68%. In America 40%, and in Europe and Central Asia 25%. The report also shows that 93% of informal employment in the world is in emerging and developing countries.[105]

In words of Rafael Diez de Medina, Director of ILO's Department of Statistics;

> *"The high incidence of informality in all its forms has multiple adverse consequences for workers, enterprises and societies and is, in particular, a major challenge for the realization of decent work for all and sustainable and inclusive development."*[106]

This is why multilateralism is essential. External support, with collections also from other states through the carbon tax, would guarantee the start of a transition towards a sustainable formal economy that allows to allocate resources to poverty reduction while achieving: reduction in dependence on the use of fossil fuels, implementation of a comprehensive policy for the conservation of sensitive ecosystems, stimulation of energy efficiency projects or promoting development, research and investment in renewable energy, among others.

3.2 The Treaty

To guarantee that there is no carbon leakage and to guarantee support for developing countries, among other advantages offered by the multilateral and universal nature of the instrument, it must be correctly stipulated in a multilateral treaty.

3.2.1 Sections

The objective of this paper is not the draft of the treaty itself, but to capture the need for the existence of a common and regulated economic instrument, so it is

[104] Oxfam. Sterrett, C. (2007, December 04). *Oxfam International Financing adaptation: Why the UN´s Bali Climate Conference must mandate the search for new funds.* Oxfam Briefing Note, December 2007. Pp 3-4. Retrieved April 04 from: https://policy-practice.oxfam.org.uk/publications/financing-adaptation-why-the-uns-bali-climate-conference-must-mandate-the-searc-114509

[105] ILO. (2018). *Women and men in the informal economy: A statistical picture*. Retrieved April 04, 2020 from: ISBN 978-92-2-131580-3, 978-92-2-131581-0.

[106] ILO. (2018, April 30). *More than 60 per cent of the world's employed population are in the informal economy.* Retrieved April 04, 2020 from: https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_627189/lang--en/index.htm

convenient to lay the foundations at least of the treaty, and define the main sections that it must contain.[107]

3.2.1.1 Introduction, preamble

In this first section of the treaty, some of the key provisions of the UNFCCC should be remembered. Highlighting the obligations to preserve the environment. Recalling the need for action in order to limit the rise in temperature to 1.5°C, and clarifying that the sovereignty, territorial integrity and political independence of all States will be respected.

3.2.1.2 General principles and provisions

In this second section, the first articles will refer to the terminology applied in the following articles of the treaty. This first part should also include the objectives of the treaty, and the principles that it will follow. Some of these principles, recognized in other treaties such as the United Nations Framework Convention on Climate Change, could be those already stated above such as the common but differentiated responsibilities and their respective capacities or the equity principle. In addition to the precautionary principle, which requires that in the event of a threat to the environment and in a situation of scientific uncertainty, appropriate measures should be taken to prevent damage.[108] Another principle of great utility in this treaty would be the non-regression principle, which seeks to avoid regulatory suppression or a reduction of its requirements for purposes that are not legally superior to the environmental interest.[109]

This part of the treaty should also include the relationship with other previous regulations such as the Paris agreement, and the relationship with other jurisdictions that have already adopted a higher carbon tax than the initial tax rate of the treaty, unilaterally or regionally, but without going into details, since the next point addresses it more broadly.

3.2.1.3 Nature of the tax

This part establishes the taxable base, the tax rate and the progressivity, that is, the annual progressive increase in the tax rate, as provided in section 2 of this paper. As cited in the previous section, in this part of the treaty, should appear the articles in relation to the commitments already established by the different jurisdictions that already have a carbon tax, if are lower, the rate must be raised to the one established in common by the Treaty, and if it is higher, it will be maintained until the rate of the carbon tax of the agreement is greater, and in that case, it should be equated. The application is mandatory for the signatory states.

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[107] Therefore this section does not have the extension, and the specification that a treaty of these characteristics would have, but rather shows the basic points that it should contain.

[108] Escalante, C.J. (2005). P*rincipio de precaución y medio ambiente*. Revista Española de Salud Pública.79(2), pp. 133-144. Retrieved April 11, 2020 from: http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1135-57272005000200003&lng=es&tlng=es.

[109] Arias, Á. M. (2016). *El principio de no regresión en el Derecho ambiental.* Retrieved April 11, 2020 from: ISBN:978-84-9890-295-2

3.2.1.4 Redistribution of revenues

The treaty must establish the use of the revenues derived from the carbon tax. Although each state may adopt the measures of the use of tax revenues, that seem more effective in its jurisdiction, pursuant to the provisions of point 2.4 of this work, a fixed percentage will go to the common fund. This is a sensitive point, since the treaty must try to be as ambitious as possible, but on the other hand, have the maximum signatory states. Therefore, the fact of establishing a common percentage should not exclude any State in the Treaty. As the OECD points out, a gradual application of a tax generates greater acceptance in society, and in the same way, the same logic could be applied to the % for the common fund.[110] So this gradual application added to the need for action could convince a large number of States, which would make the materialization of the treaty effective.

The common percentage will go to different purposes; the main one is to reduce the economic impacts derived from the tax, which fall on the consumer due to inflation in fuel prices, paying special attention to most vulnerable states to it, and the most affected by climate change. In these articles of the treaty, in addition to fix the common percentage, the use of the revenues in complementary measures to achieve greater ambition in mitigation and adaptation measures will be established.

3.2.1.5 Institutions

This section will establish a framework for the institutional arrangements. First, the collection system will be defined. Taking advantage of the already established tax structure of the different jurisdictions, the tax will be collected directly in each State. Then, the different States will be in charge of sending the percentage of the collections destined to the common fund.

On the other hand, the mandatory institutions that would be in charge of auditing the tax collection processes should be profiled and ensure that the emission measurements are correctly prepared. An important consideration to take into account is deciding whether the compliance body should be composed of representatives of the Parties or independent experts, in order to ensure the development of procedures and mechanisms to guarantee compliance.

3.2.1.6 Financial resources [and financing mechanisms]

Articles referring to financing mechanisms should be included in this part of the treaty. As previously stated, each state must contribute to a common fund with a fixed percentage of the tax collections, which in addition to the uses abovementioned, will also serve as a source of financing.

A new common fund could be established, or raise the possibility of using the Global Environment Facility as the common fund and financial mechanism of the treaty, as it is used in other treaties such as the Convention on Biological Diversity[111]. This option seems economically more efficient than the creation of a new fund, since it has the participation of 183 countries in association with international institutions, civil society

[110] OECD. (2010).*Tax Policy Reform and Economic Growth,* OECD Tax Policy Studies, No. 20, p. 72 OECD Publishing, Paris. Retrieved April 11, 2020 from: https://doi.org/10.1787/9789264091085-en.
[111] United Nations. (1992, June 5). *The Convention on Biological Diversity of 5 June 1992 (1760 U.N.T.S. 69*). Retrieved April 25, 2020 from: https://www.cbd.int/doc/legal/cbd-en.pdf

organizations (CSOs) and the private sector.[112] This fact would endow the Global Environment Facility with more funds, and could help the application of the tax in the countries least developed and most affected by climate change. These articles will also establish the possibility for Parties and non-Party States, international organizations, regional development banks and other financial institutions to provide financial resources, through voluntary contributions, to counteract the initial adverse effects, for better subsequent management, and for being able to carry out complementary measures.

3.2.1.7 Other sections

In addition to the provisions set forth above, the draft treaty should include articles regarding the settlement of disputes, urging the use of negotiation, investigation, mediation, conciliation, arbitration, judicial settlement or other peaceful means. The treaty must also include articles on ratification, approval or accession, as well as the entry into force of the treaty, and possible withdrawal clauses. Moreover, due to the nature of the treaty, it should be added a prohibition for reservations and exceptions.

4. Conclusions

The current situation, which exceeds the 415 parts per million (ppm) of CO_2 air concentration for the first time in all of human being history, makes the emergency closer than ever, and looking for a solution is inevitable. In order for the planet not to heat more than 1.5°C, the CO_2 emissions must not exceed 450ppm, a figure that is getting closer, at a rate of emissions that grows year after year, which requires an urgent change. The change must be cost-efficient, that is, the maximum emission reduction has to be obtained for a given level of expenditure. A carbon tax meets the stated objective and also offers stronger incentives than other instruments to develop more efficient technologies. The tax is capable of achieving a net cut in carbon emissions, since companies, in order to reduce the amount of the tax, will have an additional incentive to reduce their emissions.

The carbon tax also offers real redistributive advantages among the different income groups, within the framework of the different realities of each State, recycles other taxes and is capable of altering fuel prices to achieve a reduction in demand. This makes the carbon tax the most effective solution, within the economic instruments, but for this, it must be endowed with universality. The worldwide application will allow to carry out coordinate institutional modifications in order to guarantee global climate stability. Otherwise, climate change will have serious implications not only for the stability of the economy and markets but will also cause impacts for the survival and sustainability of human life on the planet, so the future generations will be condemned. However, recent history shows that both multilateral agreements and individual policies carried out have been insufficient; regional climate change mitigation policies have been strongly led by the European Union (with initiatives such as the European Program on Climate Change, the Energy Action Plan or the European Union Emissions Market[113]) although a large number of national emission reduction plans can be quantified around the world. However, the need for multilateral action involving all countries must be recognized.

[112] GEF. (2019, October 31). *Organization.* Retrieved April 11, 2020 from: https://www.thegef.org/about/organization
[113] EU. (2017, February 16). *European Climate Change Programme.* Retrieved April 12, 2020 from: https://ec.europa.eu/clima/policies/eccp_en

Climate change is a global problem where partial policies are inefficient, requiring a common institutional framework and effective environmental policies at the national and international levels that revolve around this carbon tax. In this process, it is crucial to establish an efficient criterion for allocating the resources derived from the tax between the different countries, a subject full of controversy and one of the main stumbling blocks in signing this possible treaty, despite the fact that it becomes inevitable to assume common responsibilities. The most important attempt to establish a common commitment was the Kyoto Protocol, which was governed by the principle of producer responsibility, assigning emissions according to where are produced regardless of the place of consumption. At this point, emerging countries and large exporters (such as China) supported their refusal to sign the agreement, making clear that is one of the points of maximum friction when it comes to reaching a commitment that includes all countries. These countries mostly propose shifting responsibility towards the consumer, each country being responsible for the emissions generated in the production of the goods it consumes, which is also not an effective solution.[114]

Therefore, the solution is through the application of the shared responsibility criterion to the carbon tax, an intermediate responsibility allocation system that aims to involve all agents that are in the process. Countries must show real commitment, so companies and states cannot evade their environmental responsibility through the delocalization of their production, for example. This loss of sovereignty in the matter passes into the hands of a new international framework that can bring about theb severe emission reductions that are necessary according to the IPCC, with universal participation and with the focus on emerging countries.[115]

In short, climate change requires an international response, built on a shared recognition of long-term goals and agreement on frameworks for action. In this context, the setting of a global carbon tax becomes the most effective economic tool to mitigate the effects in both the short and long term and save on adaptation measures for not having acted in time.

In the words of former Secretary General of the United Nations Ban Ki-Moon; *"Climate Change is the defining challenge* of our *age*[116]*"*.Therefore, the way we face this challenge today will mark the fate of future generations.

[114] Zaks, D. P. M., Barford, C. C., Ramankutty, N., Foley, J. A. (2009). *Producer and consumer responsibility for greenhouse gas emissions from agricultural production—a perspective from the Brazilian Amazon*. *Environmental Research Letters,4*(4), 044010. Retrieved April 12, 2020 from: https://iopscience.iop.org/article/10.1088/1748-9326/4/4/044010

[115] Lenzen, M., Murray, J., Sack, F., Wiedmann, T. (2007): *Shared Producer and Consumer Responsibility – Theory and Practice.* Ecological Economics, vol. 61 (1), pp. 27-42. Retrieved April 12, 2020.

[116] Declared at the press conference of the presentation of the synthesis report of the Intergovernmental Panel on Climate Change on November 17, 2017 in Valencia. Ban Ki-Moon*: "Reducir e invertir el cambio climático es el reto que define nuestra época".* (2007, November 17). (online video) Retrieved April 12, 2020 from: https://elpais.com/sociedad/2007/11/17/actualidad/1195254001_850215.html

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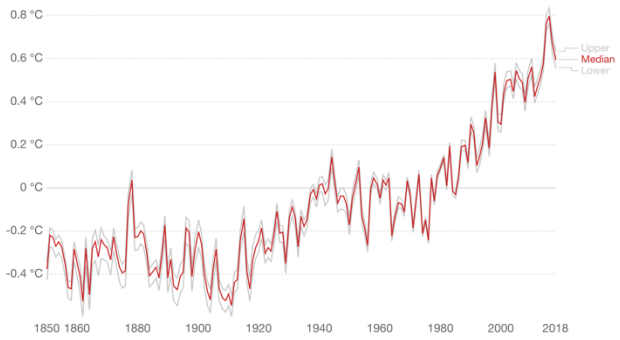
Annex

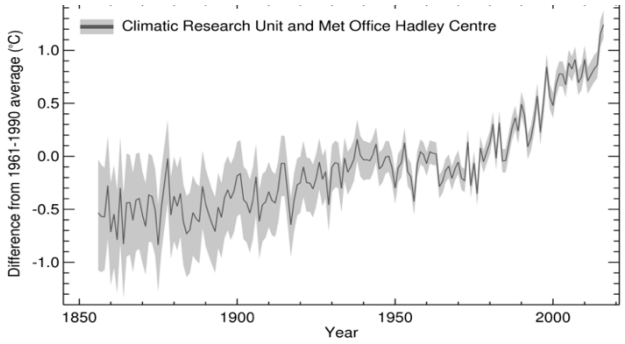
Figure 1:

Median temperature anomaly from 1850-2018 average. Data from: Met Office Hadley Centre.



Related graphics:

Global average temperature anomaly over land 1850-2016. Data from: Met Office Hadley Centre.



Global average sea-surface temperature anomaly 1850 -2016.

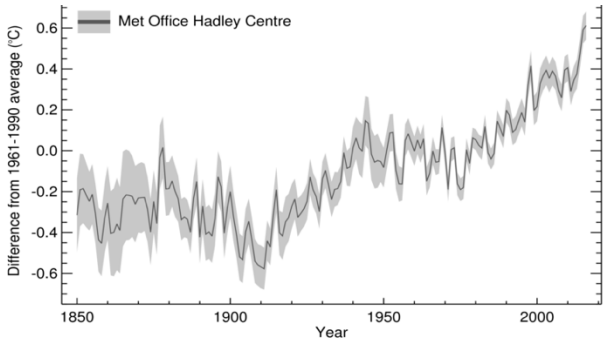


Figure 2:

Graphic of the social optimum of the quantity of energy produced according to the production with fossil fuels price.

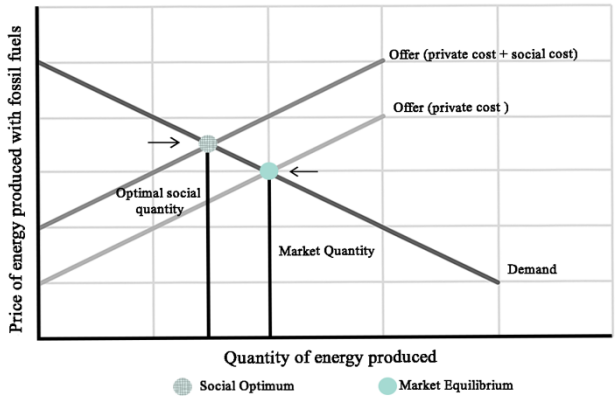
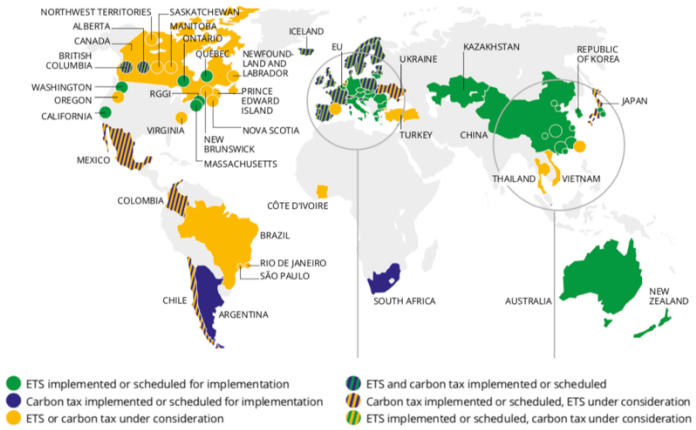


Figure 3:

Summary map of regional, national and subnational carbon pricing initiatives. (60 Carbon pricing initiatives selected, 46 national jurisdictions are covered by the initiatives selected and 31subnational jurisdictions are covered by the initiatives selected).



Full program reviews of the different initiatives available in: https://carbonpricingdashboard.worldbank.org/map_data

Example of how it works:

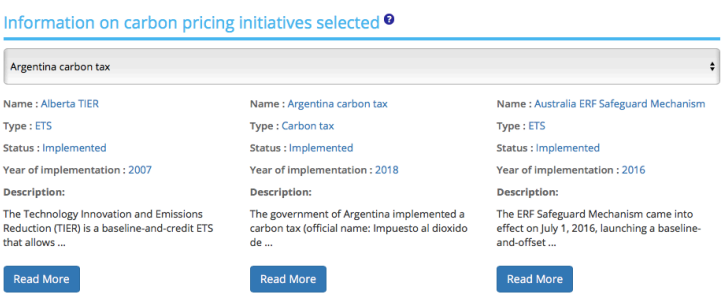


Figure 4:

First figure of the Climate Action Incentive Payments of the Canadian initiative. Average cost impact per household of 2,6 people of the federal system.

Province	**2019**	**2020**	**2021**	**2022**
Ontario	$244	$357	$463	$564
New Brunswick	$202	$296	$386	$470
Manitoba	$232	$342	$447	$547
Saskatchewan	$403	$588	$768	$946

Figure 5:

Second figure of the Climate Action Incentive Payments of the Canadian initiative. Average Climate Action Incentive payment per Household.

Province	**2019**	**2020**	**2021**	**2022**
Ontario	$300	$439	$571	$697
New Brunswick	$248	$365	$476	$583
Manitoba	$336	$495	$649	$797
Saskatchewan	$598	$883	$1,161	$1,419

Figure 6:

Third figure of the Climate Action Incentive Payments of the Canadian initiative. Climate Action Incentive payment for a family of four.

Province	**2019**	**2020**	**2021**	**2022**
Ontario	$307	$451	$588	$718
New Brunswick	$256	$377	$495	$607
Manitoba	$340	$499	$654	$801
Saskatchewan	$609	$903	$1,189	$1,459

Figure 7:

Fourth figure of the Climate Action Incentive Payments of the Canadian initiative. Climate Action support to universities, hospitals, schools, municipalities, non-profits, and Indigenous communities.

Province	**2019 to 2020**	**2020 to 2021**	**2021 to 2022**	**2022 to 2023**	**2023 to 2024**	**Total**
Ontario	$50 M	$75 M	$100 M	$125 M	$125 M	$475 M
Saskatchewan	$15 M	$25 M	$30 M	$40 M	$40 M	$150 M
Manitoba	$5 M	$10 M	$15 M	$15 M	$15 M	$60 M
New Brunswick	$3 M	$4 M	$5 M	$5 M	$5 M	$22 M

Figure 8:

Fifth figure of the Climate Action Incentive Payments of the Canadian initiative. Support for small and medium-sized businesses.

Province	**2019 to 2020**	**2020 to 2021**	**2021 to 2022**	**2022 to 2023**	**2023 to 2024**	**Total**
Ontario	$105 M	$155 M	$205 M	$255 M	$255 M	$975 M
Saskatchewan	$30 M	$45 M	$60 M	$80 M	$80 M	$295 M
Manitoba	$15 M	$20 M	$25 M	$35 M	$35 M	$130 M
New Brunswick	$5 M	$10 M	$10 M	$15 M	$15 M	$55 M