Geopolitics of Energy and Game Theory[1]

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Content

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I. Introduction

1. The Bathtub Theory

In 1975, the great US economist William Nordhaus, Nobel Prize Winner for Economics in 2018, coined a famous metaphor to describe the oil market:[2]

> "We can see the oil market as one giant bathtub. The bathtub contains the world's stocks of oil that have been extracted and are available for purchase. There are taps in Saudi Arabia, Russia, the United States and other producers that unload it into the tank; and there are stopcocks through which the United States, Japan, Denmark and other consumers extract oil from the tank. However, the price and dynamics of quantities are determined by the sum total of those supplies and demands and the total level of the tank, and this is independent of whether the taps and stopcocks are labelled "United States", "Russia" or "Denmark".
>
> Why is unrefined oil an integrated world market? The reason is that the cost of transporting oil is low, the unrefined oil from different geographical origins (and its by-products) is interchangeable to a large extent, and the different oils can also be mixed. All of this means that oil is fungible: insufficiency in one region can be made up for by sending identical or similar oil from another part of the world".

In my opinion, Nordhaus' "global bathtub" metaphor can also be applied to another chemical element associated with energy, not as a source thereof but as a consequence of the combustion of its fossil variants: carbon dioxide (hereinafter CO_2), which is emitted into the global atmosphere by burning coal, oil or gas anywhere in the world and constitutes a major part of the green-house gases responsible for global warming.

[2] NORDHAUS, William, "The Economics of an Integrated World Oil Market", Keynote Address, International Energy Workshop, Venice, Italy, June 17-19, 2009.

The big difference is that the "CO_2 bathtub" has a very narrow drain, because the natural mechanisms of absorption - such as forests, marine plankton or the sea's surface – only have a limited capacity, and efficient technologies have not yet been invented that allow for "carbon capture and storage" (or, in its abbreviated form, CCS). As we shall see, the level in the CO_2 bathtub has shown a sustained growth since pre-industrial times, driven mainly by the industrial countries –led by the USA- but also, more recently, by the most populated developing countries –such as China, India and Brazil-.

The taps that supply the two bathtubs are scattered throughout the world –although until recently the oil taps were highly concentrated in the Persian Gulf-, and those who control those taps -and in the case of oil, the outlet stopcocks- are many, are scattered the world over and can hardly coordinate themselves, in spite of the fact that as their decisions affect the bathtub level, they affect everybody.

That multiplicity and scattering of participants, and the reciprocal influx of their decisions via their impact on oil prices and the CO_2 level built up in the atmosphere, produce in those two areas some classic phenomena described by Game Theory , that branch of mathematical analysis of the Economy that studies interdependence situations, in which the result of the decisions that someone takes –known as a "player"- depends decisively on the decisions or performances of other "players".

Despite the development of the "liquid natural gas" market (LNG) in recent years, the natural gas market does not yet constitute a great integrated international "bathtub", because the supply of gas through pipelines that cross many countries prevents the gas markets from being fully integrated. Nevertheless, the dependence between the supplying and using countries that those networks of gas pipelines bring about will sometimes have a geopolitical dimension that, as we shall see, can also be analysed from the perspective of Game Theory.

2. Game Theory

Game Theory is currently a sophisticated mathematical approach for establishing the best course of action in the face of uncertainty –especially when that uncertainty comes from how the others behave-. But here we will use a simplified version, which shows the interdependence of two or more persons –called "players"- by means of a matrix in whose rows the potential alternatives of the first player are indicated and where those of the second are shown in columns. The results ("pay offs") that the two players will obtain under each combination are shown in each box.[3]

One of the major contributions to Game Theory is that there are certain archetypical matrix structures that appear in very different social situations, which makes the incentives and dilemmas affecting the players conceptually similar. Some that come up in international energy markets will be analysed below.

The Prisoner's Dilemma

This game, which strictly speaking we should call "dilemma of the arrested", was described in 1950 by the US mathematician Albert Tucker and was inspired by a technique used by the police and prosecutors to undermine solidarity and connivance between a gang of criminals with the promise of privileges if they betray their accomplices and provide the police with evidence that make it easier to successfully prosecute them.[4]

Let's imagine that the police have detained two criminals and are interrogating them separately. The criminals have committed the crime, but the police only have evidence against them for other less serious offences. The prosecutor can separately promise

[3] There is a great deal of economic literature about Game Theory. It began with VON NEUMANN, John and MORGENSTERN, Oskar, "Theory of Games and Economic Behavior", Princeton University Press, 1944. A classic and elementary introduction is provided by MORTON D. DAVIS, "Game Theory. A Nontechnical Introduction", Dover Books on Mathematics, 2003. Other straightforward and recommendable books are BRAMS, Steven J. "Negotiation Games. Applying Game Theory to Bargaining and Arbitration", Routledge, 1990; and RASMUSEEN, Eric, "Games and Information. An Introduction to Game Theory", Willey-Blackwell, 2006.

[4] An elementary and entertaining analysis can be found in POUNDSTONE, William, "The Prisoner's Dilemma", Alianza, 2006.

each of them that if he confesses to the crime and betrays the other one, he will be released and no charges will be brought against him (whereas the other one will be given a 10-year prison sentence). However, what he will not tell them is that if the two collaborate, the confession will be of little use to either of them, and they will be condemned to, let's say, 5 years; and if neither of them confesses, they will only be sentenced to 1 year, for those lesser offences. The situation can thus be summed up as follows (the figures amount to years in prison, the first for criminal A and the second for criminal B):

		Player B	
		Confess	Not confess
Player A	Confess	-5 -5	0 -10
	Not confess	-10 0	-1 -1

Isolated and unable to coordinate, both of the arrested criminals will conclude that it is in their own interest to confess, regardless of what his accomplice does. Because if A thinks that B is weak and will confess, he had better anticipate the other's confession and do so first, otherwise he will face a 10-year sentence and be the sucker; and if he thinks that B will be loyal and keep quiet, criminal A, an unscrupulous individual, will find out that if he betrays him he can take advantage of the situation and be released. Therefore, A will come to the conclusion that he must confess. Yet B's process of reasoning will be similar, and he will conclude that it is also in his own interest to confess. In the end, both of them will confess and be condemned to 5 years, in spite of the fact that if they had kept quiet they would have only been given a 1-year prison sentence.

This is the "prisoner's dilemma" in a nutshell: the players would have probably been prepared to collaborate with each other if they were both certain that the other would do

likewise. But in the face of doubt, the fear of playing the “sucker” if they are the only one who cooperates and the temptation to take advantage of the other’s cooperation will inevitably lead each player to act in his own interest, which will mean that both lose out by not collaborating.

In the real world, there are many social situations with a structure similar to a “prisoner’s dilemma”. These are just some examples:

- Paying taxes: for all citizens the ideal would be that everybody pays taxes, except for themselves. However, if we rule out this ideal situation, we all prefer to pay taxes than for the fraud to be widespread and the State to have no tax revenue.

- Arms races: two rival powers may prefer to limit their arms at the same time, instead of embarking on a costly rearmament. Yet unless they agree to an effective mechanism that penalises whoever goes ahead with unilateral rearmament, both countries, prisoners of mistrust, will be unwillingly drawn into an upward spiral of military expenditure. Similarly, they may actually start a war, nuclear or conventional, if they suspect that whichever power attacks first will obtain a great advantage ultimately leading it to victory.

- Workers’ strikes: under the assumption that all a company’s workers share the same interests, they can all have a collective interest in imposing certain employment conditions on the employer. However, each worker would be tempted to give way to individual pressure, or not participate in the strike and be “scabs”, while at the same time benefiting from the improvements achieved by their colleagues.

But there are also two cases directly related to the international energy market:

- Artificially inflating oil prices.

  As always happens within a “cartel” or collusive agreement among producers of an homogeneous asset –such as oil-, all the producers will have a joint interest in the

price of the product being high, which would make it necessary to limit the supply by establishing individual quotas; yet once that high price is achieved, each producer will be tempted to raise its production to a maximum, to cash in on the high price.

As we shall see later, this is a dilemma often faced by the Organisation of the Petroleum Exporting Countries (OPEC).

- Limiting the global emissions of greenhouse gases.

  As we have already pointed out, the emission of CO_2 and other gases (methane, nitrogen oxides, etc.) and their build-up in the atmosphere causes a "greenhouse effect" that is warming the Earth, a phenomenon that can have a very negative impact. Therefore, all countries have a collective interest in moderating world emissions, or even eliminating them altogether. However, as reducing them requires sacrifices, each one will be tempted to "free ride" and make sure it is the others that collaborate in this effort.

One of the best known techniques for coping with the risk of "free riding" in situations with a "prisoner's dilemma" structure is to commission a "Leviathan" – to use the biblical term coined by Thomas Hobbes, the 17th Century British philosopher - to punish those who will not collaborate, given that the "fear instilled by that power and that force, can turn all the wills towards trying to reach peace *within* and to providing mutual aid against the enemy *without*".[5]

Yet on the international energy market there is no Leviathan to take on this task, although on occasions there is a leading country -Saudi Arabia, in the case of the OPEC- that endeavours to play the role of coordinator and puts the spotlight on those producers that do not pull their weight in this collective effort.

The Trust Game

[5] HOBBES, Thomas, "Leviathan", Chapter 17, "On the Causes, Generation and Definition of a Commonwealth".

A special variant of the “prisoner’s dilemma” results on the energy market from the heavy initial outlay that many projects require (prospecting oil deposits, extracting natural gas, constructing natural gas liquefaction plants, etc.), because these investments can only be recouped and made profitable with the future income which the project produces. However, will it be sensible to undertake or finance the project if there is a serious risk that in future years the sale price plummets or the authorities take measures that curtail its profitability?

This dilemma is illustrated by the “trust game” or “investment game”, drawn up in 1995 by a group of economists led by the American Joyce Berg.[6]

Let’s imagine that we give 10 euros to Player A –who will play the role of “investor”- and we tell him that he can keep them or, if he prefers, transfer them, completely or partly, to Player B –which will be, let’s say, the host country to the investment. If Player A transfers any euros to B, the game organisers will make a supplementary contribution –the social profitability of the project-, so that B will obtain three times the amount sent by A (thus, for example, if A transfers 7 euros, B will receive 21). However, once B receives that amount, he will be free to decide how much to keep and how much to return to A (so, nothing will prevent B from keeping all that he receives, without returning anything to A). In such circumstances, how many euros should A send to B?

[6] BERG, Joyce, DICKHAUT, John, and MCCABE, Kevin, “Trust, Reciprocity and Social History”, Games and Economic Behavior, 1995, nº 10, available at http://community.middlebury.edu/~jcarpent/EC499/Berg%20et%20al%201995%20GEB.pdf

		Player B (Sovereign)	
		Return a lot (e.g. half of the earnings)	Not return any
Player A (Investor)	Invest a lot (e.g. invest 10)	+5 +15	-10 +30
	Not invest anything	0	0

In view of the potential profitability of the project –the initial investment is tripled-, the more money A invests, the bigger the "cake" to be shared. So, if A sends his 10 Euros, B will receive 30, the maximum possible. But ... What happens if B keeps the lot, and gives back to A less money than A sent?

The situation is described in the table, in which Player A plays the role of "investor" and Player B is the State hosting and benefiting from the investment, which can decide, once the investment is made, what profitability to allow the investor to have.

The structure of the "trust game" is, in fact, that of a prisoner's dilemma, given that if the investor does not put enough faith in the future behaviour of the sovereign, the game will end in a "non-cooperative" solution: A will not invest anything and neither party will receive any of the net earnings that the initial investment could have yielded.

In the economic literature, the term “stranded” assets has been used to refer to those investments already made that for unexpected reasons cannot be recovered, such as the euros sent by Player A when Player B does not reciprocate. We shall later examine the nature of those risks that affect the major energy projects.

The Chicken Game

The name of this game comes from the analogy that the British philosopher Bertrand Russell used in 1959 in his book *“Common Sense and Nuclear Warfare”* to describe the conflict that confronted the two major nuclear powers of the period –the United States and the Soviet Union- in which he drew a parallel with the game played in pairs by some American adolescents: from the driving seats of their cars they started up from a distance and drove towards each other on a collision course –like in a Medieval jousting tournament- and the one who swerved first to prevent a head-on crash was the loser or “chicken”. The game appears in the film “*Rebel without a Cause*” starring James Dean, the only difference being that the cars ran side by side towards a cliff and the winner was the last driver to jump clear of the vehicle. Russell found this game to be a metaphor of the conflict between the two nuclear powers of the period and of the brinkmanship tactic pursued by the American Secretary of State, Foster Dulles –namely allowing international crises to accentuate, even at the risk of triggering a nuclear holocaust.

However, not long after, in his book “*Arms and Influence”* (1960), the American economist and 2005 Nobel Prize Winner for Economics, Thomas Schelling, pointed out that the game had already been described in Homer’s Iliad in Book XXIII, when the young Antilochus snatches the runner-up’s place from Menelaus in the race in one of the funeral games in which Achilles honours the death of Patroclus. Antilochus, who is aware of the fact that the wheels on his chariot are slower than his rival’s, takes his father’s advice and, shortly before some rocks narrow the track, places his chariot to the left of Menelaus’ and whips up the horses. Menelaus becomes alarmed and reproaches him: “Antílochus! You’re riding your chariot dangerously- Slow the steeds down; the track is narrow now, and as soon as it widens, you can get ahead of me. Let’s not crash and injure ourselves all because of you”. “But Antílochus –concludes Homer-, as though

he had not heard him, spurs his horses on. Menelaus' mares slow down, and Menelaus voluntarily stops using the whip, so the horses won't trip each other up, overturn the chariots and cause the charioteers to fall into the dust in their eagerness to win the race".

The structure of the Chicken Game is described in the table below:

		Player B	
		Cede	Stand one's ground
Player A	Cede	0 0	-10 +10
	Stand one's ground	+10 -10	-100 -100

As we can see, the best thing for each player is to be cold-blooded, take the rival to the brink (*brinkmanship*) to intimidate him and force him to cede, thereby obtaining an advantage at his cost. If that is not possible, the next best thing is for both players to cede simultaneously and the game will end all square. Yet if this is not possible either, the best thing is to cede to the rival and be called a "chicken", but to survive, because the worst result possible is to lose one's life in the wager, which is what will happen if neither "cooperates". Hence the big difference with the prisoner's dilemma, where the worst outcome is cooperating when the other player does not.

A famous historic example of this sinister "game" took place in 1962 during the Cuban missile crisis between Kennedy and Khrushchev.[7]

Although the theoretical analysis of the game does not enable one to know who cedes, the one who will do so in practice, like Menelaus, is likely to be the more sensible and

[7] An entertaining account appears in BRAMS, Steven J., "Paradoxes in Politics. An Introduction to the Nonobvious in Political Science", The Free Press, 1976, Chapter 5.

responsible player, or the one who, like the former Russian leader during the Cuban crisis, had less at stake in the wager.

In the international energy market chicken games may be at play in situations where one of the parties, a major energy consumer with supply sources that are not very diversified, comes to depend heavily on a major supplier, who can take advantage of this dependence to threaten the former with suddenly cutting off the supply and compel it to submit to its wishes.

Note that in the chicken game both parties suffer from catastrophic consequences if neither cooperates and the conflict becomes real. In the case of energy, that can also happen when the energy supplier is also heavily dependent on its customer, depends on its sales and, as a result, cannot afford to cut off the customer's supply. Yet, even if this is the case, the supplier may be able to intimidate those who depend on its supply by pretending that it can bear the revenue loss.

The situation changes when the game is no longer symmetrical and the consequences of a lack of cooperation are different for the players concerned. That is the case with the "called bluff", which we will now proceed to analyse.

The Called Bluff Game

This game, described by Glenn Snyder and Paul Diesing, helped them to analyse some international crises in which the players' situations were not symmetrical.[8] In fact, this is a combination of the prisoner's dilemma and the chicken game.

In fact, as can be seen in the bottom right-hand cell in the table, if neither of the players cedes and both try to impose their will, Player A will come off worse than B, for whom the worst possible outcome will be ceding unilaterally (bottom left-hand cell).

[8] SNYDER, Glenn & DIESING, Paul, *Conflict among Nations: Bargaining, Decision Making, and System Structure in International Crises*", Princeton University Press, 1977.

		Player B	
		Pact	Stand one's ground
Player A	Pact	0 0	-10 +10
	Attack	+10 -10	-20 +5

Snyder and Diesing illustrate this game with the conflict in 1905-1906 between France and Germany, when the former took control over Morocco without consulting the latter, and without offering Germany any compensation –in contrast to what France had done with Spain, Great Britain and Italy-. Germany, that played the role of A, protested strongly, the Emperor went to Tangier to defend Moroccan Independence –although later he attempted to acquire his own sphere of influence in Morocco- and threatened with war, thinking that that threat would make Great Britain stop supporting France –which was playing the role of B-.

Snyder and Diesing point out that "Germany's threats during the crisis brought about a defensive and hostile reaction from France that greatly increased the value of standing firm against the enemy. One of Germany's aims was to break the entente between France and Great Britain and demonstrate that the latter would leave France in the lurch if war broke out. Its other objective was to be recognised as a colonial power, as an official member of the European Club of Major Powers with a right to be consulted about changes in the *status quo* beyond Europe. There were rifts within Germany: the Emperor attributed great value to [good relations with France], whereas [his Minister of Foreign Affairs] Holstein did not expect anything from France and demanded firmness. These rifts were one of the main reasons for German hesitations during the crisis. France expected that if the Conference ended in disagreement, Germany might declare war. However, with the guarantee of support from Great Britain, France expected to

achieve a decisive victory, whereas Germany had no real intention to start an unpopular and costly war over Morocco.

The German strategy was based upon the mistaken belief that Great Britain would not back France, that France could not afford to risk a war against Germany and that it was all a game of "chicken". The Germans thought, on the basis of a misinterpretation of certain events, that the threats would make France increasingly back down, when in fact the country's will to stand firm increased. The German strategy was not only ineffective, but also counterproductive".

In the end, Great Britain carried on supporting France, which stood its ground, and Germany, isolated and backed only by Austria, ended up by giving in to the French ambitions at the International Conference of Algeciras. The German Minister of Foreign Affairs, Friedrich von Holstein, resigned soon after.

When a conflict has this structure, one of the players thinks that it is playing a symmetrical game of "chicken", in which it expects to get its own way because the rival will fear that the lack of agreement will end in disaster for both of them. Yet this belief is wrong, given that the other player does not think it is playing a game of "chicken", but a "prisoner's dilemma": a lack of agreement will not be a catastrophe for Player B, because its greatest fear is to cede unilaterally to the rival's threats.

Hence the name "*called bluff*", taken from poker: when one party threatens with a disaster -a "train crash", in the usual metaphor-, if there is no agreement, the other party, which is not making an all-out effort to prevent the conflict, prefers confrontation to an agreement or to give way. And this firmness makes the bluffer back down.

In my judgement, real world situations that have this structure are:

- Some "wildcat strikes", such as the famous one involving the North American air-controllers in August 1981, a few months after President Ronald Reagan took possession. Far from losing his nerve, the President took exceptional measures to

confront it, and managed to get those who called the strike to desist soon afterwards.

- The threat in 2015 from the new Greek Government of President Alexis Tsipras when it refused to accept the adjustment measures required by the Ministers of Economy and the Treasury for the Euro Zone as part of the Greek bailout and raised doubts about whether or not Greek would withdraw from the Eurozone.

- The challenge from the Catalan Separatists in Autumn 2017 when the Catalan Parliament passed the "Disconnection Acts" and attempted to hold a referendum about the alleged "right to decide" about Catalonia's separation from Spain, but, not long after King Felipe's speech on 3rd October of that same year, the Government applied Article 155 of the Constitution and the Prosecutor and the Courts began to take legal action against the most prominent pro-independence leaders.

In the international energy market this game comes into play when whoever feels intimidated by an energy producer or group of them attempting to exert its power by threatening to put up its prices or cut off supplies takes measures that enable him to get around those threats and ends up by preventing them from being carried out. As we shall see later, features of this game can be discerned in:

- The American producers of unconventional oil's ability to prevent the OPEC from raising the price to the high levels that it reached in the summer of 2007, by increasing their own production.

- The efforts of countries in the European Union to meet, even unilaterally, the "decarbonisation" targets set in the Paris Agreement in December of 2015 and to promote domestic renewable energy sources, with a view to reducing their dependence on imported hydrocarbons and to guarantee a better energy supply. Features of this game can also be seen in the European Union's wish to create an internal natural gas market, with a variety of supply sources, so as to reduce the dependence of the Central and Eastern European countries on Russian natural gas.

II. International Energy Market

1. Sources of Primary Energy

In 2017, the most recent year for which figures are available, primary energy consumed throughout the world amounted to 13.5 billion tonnes of oil equivalent, whose breakdown into fuel sources was as follows:

Primary Energy	Annual Consumption (million tonnes of oil equivalent)	%
Oil	4621.9	34.20
Coal	3731.5	27.61
Natural Gas	3156	23.35
Hydroelectric	918.6	6.79
Nuclear	596.4	4.41
Renewable	486.8	4.49
Total	**13511.2**	**100**

Source: BP Statistical Review of World Energy 2018, p.9

As can be observed, oil is still the main source of primary energy, followed by coal and natural gas; then, a long way behind comes hydroelectric power and the renewable energies as a whole (wind, photovoltaic, thermal solar, etc.). Such data reveal the enormity of the "decarbonisation" challenge, to which reference will be made later.

The international oil market is, as has already been stated, a global "bathtub" into which production flows from a variety of "taps" all over the world, and the oil flows out again to be consumed by refineries, trading companies and users throughout the world.

Although coal is also the subject of international trade, it is mainly consumed in the many countries that produce it. Coal is still the main source of energy in Asia, where it accounts for almost 50% of the total.

Finally, the natural gas market is in expansion, but, unlike oil, it is not a standardised "bathtub", with one single price of reference. However, it is gradually becoming integrated due to the fact that traditional supply of gas via pipelines is being supplemented by the international trading and supply of "liquid natural gas" (LNG), through liquefaction, transport by ship and subsequent regasification at destination.

2. World Energy Demand

The world energy demand can be seen as the result of multiplying three factors[9]:

- The world population.

  It is expected to carry on growing, so that the current 7.4 billion people will reach around 9 billion in 2040, as a consequence of the demographic increase in the emerging economies, led by India.

- The world income *per capita*.

  It is also expected to carry on growing and, like the population, it is directly linked to the energy demand, owing to the greater utilisation of consumer goods that require energy (vehicles, electrical appliances, air-conditioning, etc.).

- The energy intensity of the world GDP (i.e. the energy consumed/GDP ratio).

  It is a variable that depends on the energy-saving measures and on the energy efficiency of the engines and machines that use it.

[9] COPENHAGEN ECONOMICS, "The future of fossil fuels: How to steer fossil fuel use in a transition to a low-carbon energy system", Full Report for the Energy Transitions Commission, January 2017, P. 13 and following.

If the result of the aforementioned multiplication –i.e., the energy consumed in the world in one year- is multiplied by the intensity of carbon energy emissions (i.e., CO_2/Energy) we will obtain the gross annual CO_2 emissions.

The combined effect of those three factors, even taking into account the expected improvement of the third one –energy efficiency- is likely to cause an increase in the annual overall energy demand of close to 25% between 2017 and 2040, as well as a drastic change in the relative weight of consuming countries: while in 2000 the developing economies of Asia were consuming 20% of the world's energy –compared to 40% for Europe and North America-, in 2040 the percentages will have reversed, and the emerging Asian countries (led by India and China) will be consuming 40% of the world demand[10].

How will this significant increase in the global demand be catered for? Will it be possible to reconcile this with the aims of the fight against global warning that, as we shall see later, were set in December 2015 in the Paris Agreement?

3. Oil

3.1 Market Structure

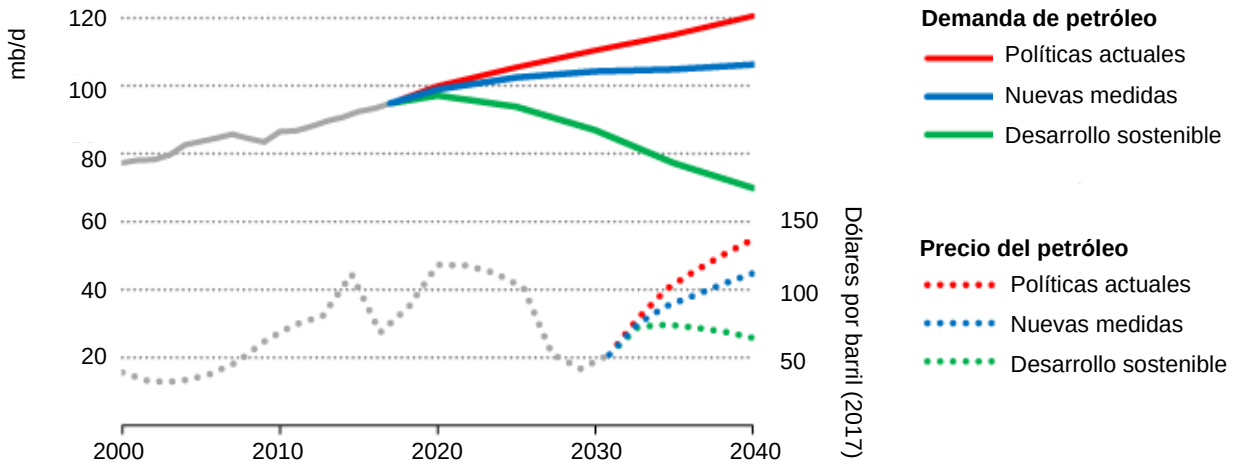
As already explained, the oil market constitutes a genuine international "bathtub" where the price for each variety (Brent, West Texas Intermediate, etc.) is the same the world over, because the transport cost –by pipeline or ship- is low. These international prices are determined at organised markets where not only the end consumers of the commodity but also many intermediaries and financial agents compete as purchasers, taking up positions on the spot, forward and futures markets and negotiate contracts with different delivery deadlines.

The global demand for oil follows a relatively stable growth pattern, which responds in the short term to the macroeconomic situation in the consumer countries –it increases in

[10] INTERNATIONAL ENERGY AGENCY, "World Energy Outlook 2018", Executive Summary, November 2018.

periods of expansion and decreases during recessions- and in the medium and long-term to the absolute growth of the population and the process of replacement by other energy sources. The world demand for oil thus shows significant “income elasticity”, even in the short term, and a “price elasticity” which is moderate in the short term - because in the short term the ability to replace oil by-products is limited, but greater in the long term.

As can be seen in the graph below, the aggregate world demand for oil has been growing steadily over the years, with only slight and fleeting drops during the periods of severe recessions, such as the crisis of 2009. Its absolute level is approaching 100 million barrels per day and its future development will depend, as the latest report issued by the International Energy Commission indicates, on which of the three major scenarios prevail: that countries stick to their current policies (hereinafter “current policies”); that they adopt the new measures to fight climate change that have already been announced (hereinafter “new measures”); or that they take the much more radical measures required to comply with the targets set in December 2015 in the Paris Agreement (hereinafter “sustainable development”). Logically, the scenario that prevail will affect the future price of oil.



Source: International Energy Agency, World Energy Outlook 2018

OIL DEMAND: CURRENT POLICIES; NEW MEASURES; SUSTAINABLE DEVELOPMENT.
PETROL PRICES: CURRENT POLICIES; NEW MEASURES; SUSTAINABLE DEVELOPMENT
Dollars per barrel. (2017)

On the supply side, in 2017 the world oil production amounted to 92.6 million barrels per day. The break-down by country of origin was as follows:

Producing Country	Production (million barrels per day)	%
United States	13	14.1
Saudi Arabia	11.9	12.9
Russia	11.2	12.2
Iran	4.9	5.4
Canada	4.8	5.2
Iraq	4.5	4.9
Arab Emirates	3.9	4.2
China	3.8	4.2
Kuwait	3	3.3
Brazil	2.7	3
Mexico	2.2	2.4
Venezuela	2.1	2.3
Nigeria	1.9	2.1
Qatar	1.9	2.1
Norway	1.9	2.1
Kazakhstan	1.8	2
Angola	1.6	1.8
Algeria	1.5	1.7
Rest	15.9	17.1
Total	**92.6**	**100**

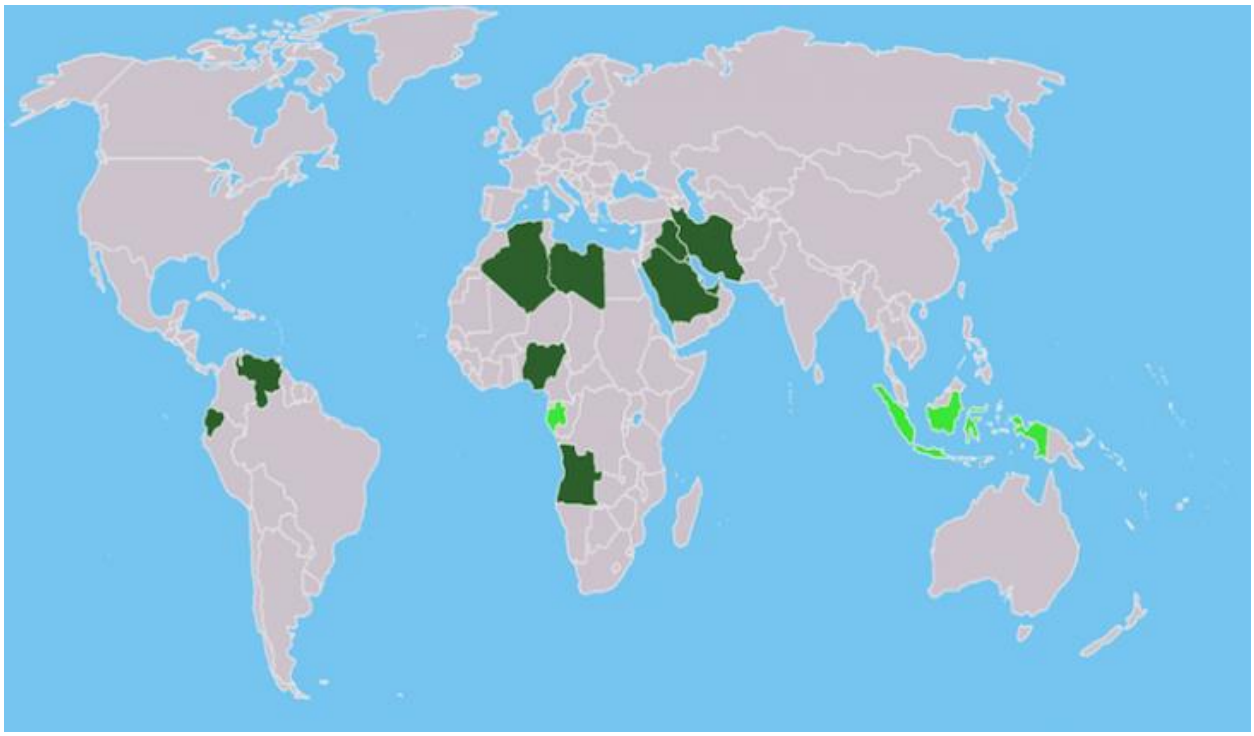
Source: BP Statistical Review of World Energy 2018, Page 14

Thus, in 2017 OPEC countries produced 39.4 million barrels per day, i.e., 42.6% of the world`s oil; and, for the first time, the United States was the world's top producer. Production in Russia was also very high, close to Saudi Arabia's.

3.2 The conventional oil market: the OPEC +

The international oil market is not a perfectly competitive market with a fragmented supply coming from small producers that are independent of each other, but an oligopolistic market where a significant group of countries formed an organisation in the early 60s -the “Organisation of the Petroleum Exporting Countries” (OPEC) - to coordinate their production decisions and influence international oil prices.

The founder members of OPEC in 1960 were four large oil-producing countries in the Middle East (Iran, Iraq, Kuwait and Saudi Arabia) plus Venezuela. Other oil-producing countries joined later, in such a way that the OPEC now has 14 members, after the recent departure of Qatar in November 2018. Qatar now concentrates on the extraction and liquefaction of natural gas, and has maintained recently tense relations with two neighbouring OPEC members, Saudi Arabia and the United Arab Emirates.[11]



The Soviet Union was never an OPEC member and had very strained relations with Saudi Arabia, as a consequence of the alliance between Saudi Arabia and the United

[11] See https://www.opec.org/opec_web/en/about_us/25.htm

States and the Soviet support for Marxist regimes in Yemen and Ethiopia. However, after the collapse of the Soviet Empire in 1990, and especially, after Vladimir Putin came to power, there have been attempts to bring Russia and the OPEC countries closer together. Although on occasions there has been talk of Russia joining the Organisation, it has merely acted as an observer during OPEC meetings.

The OPEC has sometimes accused Russia of being a free rider, as it benefitted from the rises in oil prices resulting from the OPEC production cutbacks, but without making any significant contribution to those cutbacks. This was particularly the case after the World Trade Center attacks in September 2001, when the OPEC announced that it would cut back production to prevent oil prices from plummeting as a consequence of the political commotion. Russia offered to make up for the reduction in OPEC production and the latter threatened Russia, via the Kuwaiti Minister of Oil, "with lowering the price of oil to 10 dollars, which would affect everyone, but them most of all (in reference to Russia) those whose production costs are higher".[12]

In recent years cooperation with Russia has been closer, because Russian President Putin and Saudi prince Mohammed bin Salman see eye-to eye and have a common interest in keeping oil prices high, especially after the drastic and unexpected drop that occurred in 2014. Ever since, there has been talk of an "OPEC +".

The OPEC has a proven capacity to exert a short-term influence on oil prices, because its members:

- Have been supplying over 40% of the world's oil production, and a much higher percentage of conventional oil.

- Have a massive percentage of the world's known oil reserves, which enables some of them -especially Saudi Arabia- to increase their production with relative ease, at least in the short term, thereby affecting international oil prices.

[12] ELASS, JAREER y MYERS JAFFE, AMY, "The History and Politics of Russia's Relations with OPEC", James Baker III Institute for Public Policy, Rice University, May 6 2009, Page 17.

Prisoner's Dilemma

In economic terms the OPEC is a cartel of producers and, as is the case with all organisations of that nature, its members –together with the major producers that are not members but benefit from their decisions, like Russia- are subject to a prisoner's dilemma, because they have two conflicting objectives:

- Each producer has an interest in the group as a whole controlling the world oil supply, in order to achieve the international price that is best for producers, taking into account the global demand situation and the risk of oil being replaced by rival products.

- However, once that high price is reached, the ideal for each producer is to increase its production to a maximum, given that when a producer has not reached its short-term production limit, the incremental (or "marginal") cost of producing an extra barrel is typically lower than the sale price.

Yet if producers yield to the temptation of increasing their production above their allocated quota, cheat on fellow members and do not keep their promises, the Organisation will lose control of the international oil price, which will slump, and all members will find their sale price aspirations thwarted.

Within OPEC, Saudi Arabia, as the leading country with the largest production, plays the role of Leviathan, tries to maintain group discipline and, as a "swing producer", contributes to price stability by adjusting its own supply and export volumes to the short-term fluctuations in demand or supply. Its weakness lies in the fact that the only way to punish "free riders" is to increase its production –or at least to not restrict it-, in order to force down the international price and "punish" the rest of the producers, but also punish itself.

Saudi Arabia has used this typical "chicken game" threat on several occasions, causing prices to plummet. This happened, for example, at the beginning of 1986 and in 2014.

The agreement reached at the meeting held on 6th and 7th December 2018 is a good example of that prisoner's dilemma structure, showing the OPEC's attempts to limit the production to control international oil prices, the hegemonic role of Saudi Arabia –as leader of the Organisation- and of Russia's external collaboration – and of the existence of an "OPEC +"-, when after gruelling negotiations an agreement was reached to cut back production by 1.2 million barrels per day when compared to the production in October of that year, of which Saudi Arabia itself accepted a significant part and Russia undertook to collaborate with a cutback of around 200.000 barrels a day.

Factors in the cartel's favour

The OPEC's traditional capacity to affect international oil prices and raise them has been favoured in the past by three factors:

- The occasional crises, wars and embargos that have weakened the production and export capacity of some major world producers, or been conducive to political decisions aimed at restricting supplies and increasing prices.[13]

  The best known episodes were the oil embargo agreed to on 17th October 1973 by the Arab OPEC countries against Israel and the countries that had supported the latter in the war that broke out on 6th October after the invasion by Egypt and Syria (the embargo was followed at the beginning of 1974 by a twofold increase in oil prices); the major restrictions imposed on production and the consequent price rises that took place first as a result of the Iranian Revolution in 1978-1979 –whose effect was aggravated by Saudi Arabia's decision in January 1979 to drastically reduce its production- and, shortly after, the Iran-Iraq War in 1980-1981; and the effects of

[13] See PASCUAL, Carlos and ZAMBETAKIS, Evie, "The Geopolitics of Energy. From Security to Survival", Chapter 1 of the collective works "Energy Security: Economics, Politics, Strategies and Implications", Brookings Institution Press, 2010. See also, the first author, "The New Geopolitics of Energy", Center on Global Energy Policy, University of Columbia, September 2015.

Iraq's invasion of Kuwait carried out in 1990-1991, initiated in August 1990 by Saddam Hussein.

- A reduction in the production capacity of several countries whose authorities, attracted by the prospect of large incomes in periods when prices were high, took over the ownership and control of domestic oil production, what in several cases brought about a reduction in the effort required for oil exploration and for the expansion of production capacity and, as was the case in the well-known fable, "killed the goose that laid the golden eggs".

  In fact, as Roberto Aguilera and Marian Radetzki pointed out, starting in the 60s and 70s there was a wave of nationalisations in developing countries that were also oil producers (Algeria, Iraq, Kuwait, Libya, Saudi Arabia, Venezuela, etc.), prompted by a wish to have better control over the extraction activity and to obtain greater benefits for the population. However, with few exceptions, that nationalisation had a harmful effect on oil companies, because politicians were appointed as managers, and they generally had little professional experience; social functions were attributed to the company that had little to do with running the business; and the income resulting from the oil sales was directly channelled to the State budget, without leaving the firms with sufficient funds to expand their production capacity or even or maintain it. This led to "government policies restricting the growth of the oil-producing capacity. Hence, the heavy taxation on the oil sector as a whole has operated like a consortium limiting the supply, whose effect on price rises has probably had greater impact that the OPEC quotas".[14]

- The increasingly close coordination between the OPEC and its leader, Saudi Arabia, on the one hand, and another major oil-producing country, Putin's Russia.

Factors limiting the cartel's power

[14] AGUILERA, ROBERTO & RADETZKI, MARIAN, "The Price of Oil", Cambridge University Press, 2016,

The producing consortium's ability to wield its "market power" and keep oil prices high is limited not only by the risk of "non-cooperation from its members inherent to all prisoner's dilemmas, but for several additional reasons:

- The adverse impact of excessive price rises on the world demand for oil, owing to its contractionary and inflationary effect in oil-importing economies.

- The political pressure that the United States has brought to bear on Saudi Arabia and other producing countries to get them to increase their production so as to relax international oil prices.

  Those pressures became particularly clear in Autumn 2018, when the US President Donald Trump, after initially putting pressure on Saudi Arabia to make up for the effects of the embargo that the United States had imposed on Iranian oil exports, intensified its pressure immediately before the OPEC meeting in December 2018, so that Saudi Arabia would not reduce its production and accepted the drop in prices that had commenced months before, a price reduction that Mr. Trump had compared to a lowering of taxes promoting economic growth in importing countries.

  The fact that the murder of the Saudi Arabian dissident and columnist for the Washington Post Jamal Khashoggi in the Saudi Arabian Consulate in Turkey was attributed to Crown Prince Mohamed Bin Salman increased President Trump's negotiating power, as Trump could down play the importance of the brutal murder as long as Saudi Arabia and its Crown Prince demonstrated their willingness not to cut back oil production and keep prices low.

Two more additional factors of recent origin will undermine the OPEC's capacity to control international energy prices and the geopolitical importance to the western countries of events in the Middle East: the discovery of alternative or unconventional oil sources in the United States -and, to a lesser extent, in Canada and other countries-; and the international efforts to combat global warming and climate change and to promote a "decarbonisation" of the world economy. When the global demand for oil

starts to wane (“peak oil”), some indeed foresee the “mother of all crises in the oil market”.[15]

3.3 The unconventional–oil revolution

The international oil and gas markets have undergone a genuine “revolution” – the so-called “shale revolution”- since the United States developed a new gas and oil extraction technique in the first decade of this century. The technique is based on the horizontal drilling and subsequent hydraulic fracturing (*fracking*) by injecting liquids and solvents under pressure into shale and sandstone deposits, and carbonates impregnated with hydrocarbons. The light oil produced in this way is habitually known as “tight oil” (i.e. oil obtained from compact formations).

Large-scale production started in the States of Texas -in the Permian Basin to the west of the State and the Eagle Ford Basin in the south- and in North Dakota -in the Bakken Shale- and led to a significant growth in US oil production as from 2008, which made up for the fall in production caused by political events between 2011-2014 in oil-producing countries such as Iran, Libya, Sudan or Syria and paved the way for stabilisation of oil prices in those years.

As a result of the aforementioned revolution, and according to the predictions from the International Energy Agency, the United States will account for over half the growth in the world production of oil and gas that will take place between now and 2025, by which time it will already be the biggest producer of both hydrocarbons, with a market share of 20% in oil and 25% in gas[16].

Unconventional-oil production has two characteristic features:

- Progressively declining production costs

[15] “When the sun sets on oil. The Middle East and Russia are ill-prepared for a low-carbon future”, The Economist, Special Report, 15th March 2018.
[16] WEO 2018, *op. cit*, Chapter 5.

Although at first the production of that type of oil was only profitable as from US $50 dollars a barrel, break-even prices are currently much lower.

- Moderate investment costs

  While the exploration and exploitation of conventional oil deposits is very costly-those easier to access were discovered and began to be operated years ago-, operating and drilling new wells of tight oil is quick and cheap, and costs only a few million dollars.

As the British journal “The Economist” explained in its memorable article “Sheikhs vs. Shale”[17], the development of unconventional oil has radically altered the economic dynamics of the international oil market: “The price of oil will be less vulnerable to shocks or manipulations. American shale oil is a genuine rival to Saudi Arabia as a marginal world producer”.

[17] THE ECONOMIST, “Sheikhs vs. Shale”, 4th December 2014, available at https://www.economist.com/leaders/2014/12/04/sheikhs-v-shale

In conclusion, the OPEC countries occasionally underwent the prisoner's dilemma typical of all collusive agreements between producers. But when the circumstances and the threats of its Leviathan, Saudi Arabia, made its members overcome the dilemma and control the supplies, the Organisation was able to intimidate the world, as it did during the classic oil crises of 1973-1974 and 1978-1979.

Two new events are weakening the OPEC's ability to control international oil prices and coerce consumer countries as in a chicken game:

- In the short-term, the United States' transformation into the world's main oil producer, with decreasing production costs that enable its producers to survive with relatively low oil prices;

- In the medium-term, the risk for traditional oil producers that international efforts to combat climate change and encourage "decarbonisation" will cause a drastic reduction in the consumption of hydrocarbons and, if successful, leave large reserves of hydrocarbons have untapped, as "stranded assets" or "unburnable fuel".

  That risk will be accentuated when a world peak oil consumption point is reached, because from that point on stiff competition will be unleashed involving all producers to dispose of their reserves before they are buried forever.

Thus, if the OPEC, together with Russia, were to attempt to sharply increase oil prices, the outcome might well be a "called bluff".

Yet, the fact that the United States has joined the group of major hydrocarbon producers, coupled with their common fear that a global decarbonisation strategy might deprive them of income and leave their major investments and hydrocarbon reserves "stranded", might forge a new coalition between all of them -United States, Russia, Saudi Arabia, Kuwait, etc.- against the international fight against climate change. A

glimpse of such a tacit coalition could be seen in December 2018 at the 24th United Nations Framework Convention on Climate Change held in Katowice (Poland).

4. Natural gas

4.1 Market structure

Natural gas was historically considered to be a mere by-product of oil extraction and in the supply contracts –which were generally long-term contracts and the purchaser was bound by the take or pay obligation- the price was linked to oil.

However, natural gas has been gradually detaching itself from oil (*decoupling*) and has firmly established itself as the cleanest hydrocarbon (its combustion also emits CO_2, but only approximately a quarter as much as coal and half as much as oil).

At present, the natural gas production structure is very different from that of oil, because although Russia is the world leader and the United States is also now among the major producers –thanks to the "shale revolution"-, the other major producers are Australia, Norway and Qatar –a major gas producer whose oil production is very limited-, plus other countries scattered all over the world (Nigeria, Trinidad and Tobago, Bolivia, Argentina, etc.).

In spite of the growing development of spot markets (hubs) where immediate gas deliveries are negotiated –their creation was encouraged by the European authorities, especially after Russia cut off the gas supply to Ukraine in Winter 2006, and Japan's sudden supply requirements after the Fukushima nuclear accident in March 2011- it cannot be said that the international natural gas market is already a "bathtub" as standardised and integrated as the oil "bathtub", because a significant proportion of natural gas is transported from the producing countries to the consumers via gas pipelines, complex infrastructures which make producing and receiving countries heavily dependent on each other.

Yet the development of a booming market for liquid natural gas (LNG) –based on the liquefaction of the gas at facilities in producing countries, transportation by ship and storage and regasification in destination countries- has helped integrate regional gas markets.

But this integration process is not complete, as borne out by the notable price differences for gas in the three major regional markets: the American, whose main price reference is Henry Hub (in Louisiana); the European, where the primacy of the British National Balancing Point is losing ground to the Dutch Title Transfer Facility (TTF); and the Asian one, where the reference prices are still the Korean and Japanese markets. To a large extent, the reason for this lack of full integration is that LNG not only entails liquefaction costs, but also transportation and storage costs which are higher than for oil.

Nevertheless, those differences are much smaller now than in the past, as a consequence of price arbitration between markets and the deliberate diversion of LNG shipments to those destinations with higher prices. That arbitration process is being favoured by the fact that competition authorities around the world –especially those of the European Union and Japan, which signed a Memorandum of Cooperation in this area in June 2017, but also in Korea, India and other Asian countries- are treating as abusive “destination clauses” which require intermediaries purchasing gas to sell it necessarily in a particular destination country, without being able to divert it to other destinations where the prices are higher, or limiting the amount of gas that can be diverted and the destinations concerned.

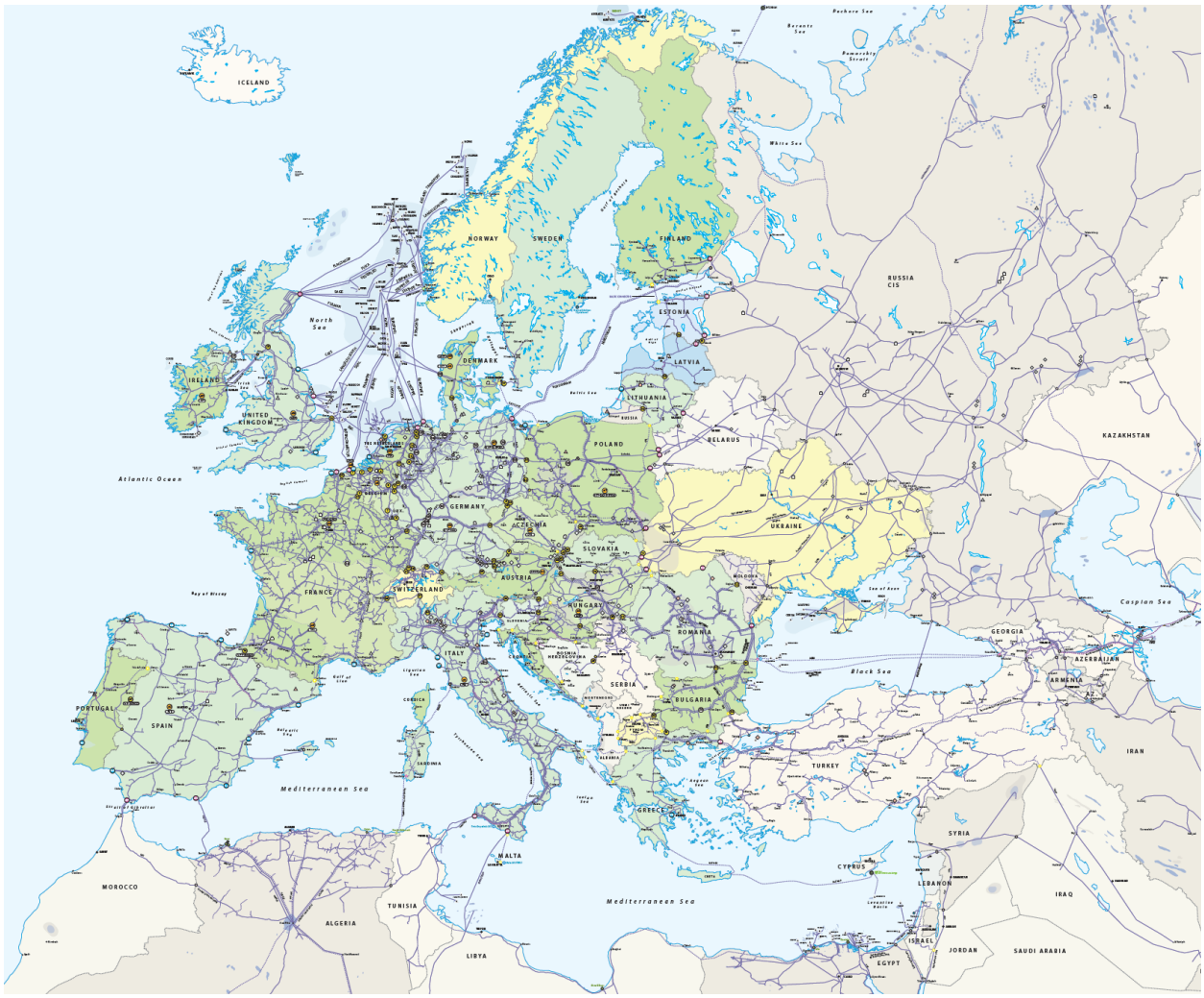
The European Union began to clamp down on these clauses when used by Russia`s Gazprom as supplier of European Union countries, but has since applied the same approach to liquid gas shipments to the European Union from anywhere in the world (Nigeria, Algeria, Qatar, etc.). In doing this, it seeks not only to achieve greater integration in the European Union regional gas markets, but also to facilitate a secure supply for the Union countries as a whole.

4.2 European dependence on Russia

Natural gas has aroused certain geopolitical concern in Europe, in view of the gradual depletion of reserves in the Dutch and British deposits in the North Sea and the great dependence of Central and Eastern European countries on Russian gas supplies via gas pipeline.

In fact, as can be seen in the graph[18], if we set aside the gas pipelines that reach Spain and Italy from Algeria and Libya and those coming from Norway, the rest of the gas pipelines that supply the countries of Central and Eastern Europe all come from Russia, either via Belarus and Ukraine, or they run along the Baltic seabed (what is known as *Nordstream 1*).

[18] Available at https://www.entsog.eu/sites/default/files/files-old-website/publications/Maps/2017/ENTSOG_CAP_2017_A0_1189x841_FULL_064.pdf of the *European Network of Transmission System Operators for Gas* (ENTSOG).



Source: The European Natural Gas Network 2017 (ENTSOG)

Some find that this structure might allow Russia to use it as an “energy arm” at the service of its geopolitical strategies, as it did with former Soviet Republics, such as Georgia, Belarus or Moldova. They point out that although Gazprom, the public company that rose from the ashes of the former Soviet Ministry of Gas, is listed on the Stock Exchange, it follows political instructions from the Russian Government. They recall that in January 2006 Gazprom cut off the gas supply to Ukraine over a dispute concerning a price increase, with the supply restrictions affecting several European Union Member States. Russia argued that the dispute with Ukraine’s Naftogaz was purely commercial, but Ukraine indicated that such a massive price increase -from 50 to 230 dollars per thousand cubic metres- was a political reprisal for the pro-western attitude of Ukraine’s new President, Victor Yuschenko.

Similarly, they argue that in January 2009 Gazprom once again cut off its supply not only to Ukraine, but also to European Union countries, given that gas was supplied mainly through the gas pipelines that cross Ukraine.

Russia cut off the gas supply to Ukraine again in June 2014, as a result of a commercial dispute between Gazprom and the Ukraine's Naftogaz; but the political background was Crimea's unilateral declaration of independence in March of that year –wholeheartedly backed by Russia- and Russian support for the separatist rebel forces of Eastern Ukraine.

Nevertheless, others have interpreted the supply of Russian gas to Germany as a continuation of the *Ostpolitik* that the Social Democrat Chancellor Willy Brandt embarked on in 1969 with its policy of rapprochement towards the then Soviet Union: establishing cooperation ties between the Soviet Union and Germany would lead, in the end, to a favourable transformation, which is exactly what happened in 1990 with the fall of the Berlin Wall.

Consistent with this view, at the end of the 90s the idea of a new gas pipeline connecting Russia with Germany via the Baltic was discussed. It was eventually named *Nord Stream*, but not laid until 2010 and not commissioned until 2011. Subsequently, to increase its conveyance capacity, a new investment costing approximately € 9.5 billion was devised (*Nord Stream 2*).

However, the concept of *Nord Stream 2* was at odds with the initiatives of the European Commission, Austria and other countries, which had unsuccessfully promoted the construction of a new gas pipeline –known as the "Nabucco Project"- to transport gas from the deposits of Azerbaijan on the Caspian Sea via Turkey, to the Balkan States, bypassing Russia to the south.

So, if the first *Nord Stream* project raised misgivings, the new project provoked outright opposition, led by Poland and the Baltic States, the European Commission, Ukraine and, above all, the United States, which threatened to impose sanctions on any firms

participating in its construction (but without actually implementing them, especially after President Trump came to power).

Those who criticised *Nord Stream 2* pointed out that it would increase German dependence on Russian natural gas and, thus, affect the European Union's foreign policy, which might be exposed to a chicken game with a major power, Russia, on which its energy depends.[19] Critics also added that it would enable Russia to act selectively against the countries -like Poland or Ukraine- through which its land gas pipelines passed, because closing those gas pipelines would not prevent Russia from continuing to supply gas to Germany and other major consumers via *Nord Stream.* Furthermore, this would also reduce the income those countries currently obtain from rights of transit passage (which in the case of Ukraine exceed 2 billion Euros a year).

Yet defenders of the new gas pipeline indicated that the dependence created would be reciprocal, as Gazprom will need the income from gas sales as much as the German purchasers will need the supply. They likewise argue that the United States' opposition to the new gas pipeline is motivated by trade interests, because the "shale revolution", coupled with the transformation into liquefaction plants of the facilities originally created on the US Coast in the Gulf of Mexico for the regasification of imported LNG, have transformed the United States into an LNG exporter that compete in Europe with the natural gas arriving from Russia.

As a matter of fact, the gas supplied by Russia via its gas pipelines is cheaper than the gas obtained by regasification of the LNG imported by ship, and this is limiting the use of LNG in the European Union[20]. As a result, it is estimated that in 2017 Russia supplied via its gas pipelines 35% of the gas consumed in the European Union.

4.3 Geopolitical Implications

[19] See, for example, in The Economist, "Germany's Russian gas pipeline smells funny to America", 22nd June 2017, "Putin's power play. The Nord Stream 2 pipeline will strengthen Russia's hand", The Economist, 19th July 2018 y "Why Nord Stream 2 is the world's most controversial energy project", 7th August 2018.
[20] "Why America struggles to sell LNG in Europe, The Economist, 16th November 2018.

As the International Energy Agency pointed out in its Annual Report issued in November 2018, “Russia is still the greatest gas exporter in the world, because it is opening up new routes to the Asian markets. However, an increasingly integrated European market offers purchasers more gas supply options”.[21]

To ensure that it is not forced to play “chicken” with Russia if the latter threatens to use its gas as a weapon, the European Union is adopting a three-pronged strategy:

- Supporting the interconnections of the European gas pipeline network, establishing new gas pipelines with exporting countries other than Russia –such as Norway- and promoting the development of one integrated and liberalized gas market in the European Union from which all the countries can be supplied under the same conditions.

- Keeping an extensive infrastructure for importing LNG, wherever it comes from, even if it is not used very often while Russian gas is the cheapest. The very fact that such installations are available for importing LNG will help to provide a secure gas supply for the European Union.[22]

- Pursuing a decarbonisation strategy, which will not only be crucial in the fight against climate change, but also reduce the European Union’s energy dependence and restrict the bargaining power of the predominant suppliers such as Russia.

Diversifying its gas supply sources, creating an efficient domestic market and decarbonisation –i.e., replacing hydrocarbons with renewable energy- are the tools that will enable the European Union to transform into a “called bluff” any threat coming from foreign gas suppliers.

[21] WEO 2018, op. cit.
[22] JAFFE, Amy Myers, “Renewable Energy, Russian Natural Gas and the Lessons of January 2006”. Blog post of Council of Foreign Relations, 26th October 2018.

5. The profitability of long-term investments

Nearly every energy production and supply project –be it conventional oil, natural gas or even renewable energies- requires major initial investments that can only be recouped in the long term, with the income generated over many years. However, as such income is likely to depend on unpredictable future circumstances, whoever undertakes or finances such investments will be exposed to serious risks.

On the one hand, as it generally happens in industries requiring high initial investments, once the investment has been made and the project is under way, "variable costs" of operation and especially the "marginal cost" of producing one more unit will be relatively low. In such a situation, as the initial will now be a "sunk cost" –i.e., inevitable-, even if the product sells at prices below the original expectations, the producer will have a vested interest in producing as much as possible, as long as his income covers his variable costs, even if he does not manage to recover the fixed costs of his initial investment. However, if many producers react that way, the glut on the market will cause prices to plummet, which will aggravate the situation of all the producers still further, and plunge them into one of those "prisoner's dilemmas" explained above.

On the other hand, if sale prices are favourable and the heavy initial investment promises to be profitable, there will be a risk that political authorities, worried about the high prices –that they will see as much higher than the marginal costs of production-, or tempted by the profitability of a company exploiting a domestic natural resource, may bring about legal changes or take measures that greatly reduce the profitability of the project.

Thus, as already explained, whoever makes major investments in the energy sector will inevitably become the "sender" in a "trust game" and will have to trust that the future combination of market conditions and the regulatory framework will make the original investment profitable, consistent with the increased wealth that it generated.

Therefore:

- If investors fear that the current regulatory framework at the time they plan their investment will not remain stable and could unexpectedly change to their detriment, they will be reluctant to go ahead with that investment. It is a deeply-rooted problem that, as explained below, we could call the “obsolescing bargain”.

- If investors are afraid that when the new installations come into operation the abundance of supply or the lack of demand will be so great the price will plummet and approach the low marginal costs of the most efficient firms, they will probably back out of new projects. This might happen in the oil and gas markets if the ideas that decarbonisation and energy transition are irreversible, that the maximum world demand for oil (peak oil) will be reached in the next 20 years and that many of the oil reserves will remain unconsumed become entrenched.[23] This is the risk known in financial markets as the “financial risk of carbon”.

  Paradoxically, if these fears were to bring to a halt investments in new hydrocarbon-based projects –e.g. exploration for new oil or gas deposits, developing natural gas liquefaction, transportation or storage facilities- some would not rule out that in the coming years there could be price tensions, especially in winter periods when energy consumption shoots up and energy production from renewable resources decreases.[24]

The risk of “obsolescing bargains”

In 1971, Raymond Vernon, a former high-ranking civil servant in the US Department of State and later a Harvard Professor, described the phenomenon that he called the “obsolescing bargain”.[25] According to Vernon, before a multinational makes an investment, it will have great bargaining power: the potential host country will be interested in attracting foreign capital and new technologies, and will be prepared to

[23] GAPPER, John, “The romance of drilling for oil has faded”, Financial Times, 29th November 2018.
[24] KHANBERG, TATIANA, “Why Continued Investment in Gas Infrastructure is not Optional”, Natural Gas World, 19th November 2018.
[25] VERNON, Raymond, “Sovereignty at Bay: The multinational spread of U.S. enterprises” Prentice Hall Press, 1971. See also, from the same author, “Sovereignty at Bay: Ten Years After”, International Organisation, Volume 35, Issue 3, 1981 and “Sovereignty at Bay: Twenty Years After”, Millennium Journal of International Studies, Vol.20, No 2, 1991. As Vernon died in 1999, he could not write any later versions.

offer the large foreign company a favourable agreement. That good relationship will last as long as the foreign company continues to invest. However, the foreign multinational will become vulnerable as soon as it has made the investment. This is because if the business is profitable, the host government and local citizens will start to argue that the foreign firm is making an exorbitant profit and fail to take into account the risks that the company took on when investing in the first place. Moreover, if the investment aroused the interest of local firms, improved the infrastructures and opened up the country to foreign capital, local authorities, seeing the range of options now being offered to their country, will review the agreement originally reached with a critical eye. By doing so, the authorities will appease local politicians and pressure groups who demand that the country recovers its economic sovereignty and do not "sell out" to foreign capital. So, the political dynamics within the country hosting the investment will end up rendering obsolete the agreement original entered before the investment was made. As in the "trust game", investors will occasionally be unable to recover the money the put into the game.

The "obsolescing bargain" phenomenon is a general problem that affects all long-term contracts or investments, when conditions prevailing at the time the contract has to be implemented give great incentives to one of the parties to break its original commitments. This risk will be particularly great:

- In long-term supply contracts, i.e. "Purchase Power Agreements" (PPA), when the parties take on a quantity commitment –e.g. for the purchaser a "take-or-pay" commitment- and set a price that may differ from spot market prices at the time the contract has to be implemented.

- In investments in renewable energies fostered by public authorities with the prospect of generous feed-in tariffs, when there is a risk that subsequent events may make those implicit subsidies financially unsustainable.

How can a political authority “bind its own hands” to convince an investor that it is not going to change the rules of the game later for no reason and make the project less profitable?

The traditional technique has been for the host country to subscribe to an International Treaty that protects investors against expropriation or unjustified regulations that harm their interests, and reconigze them a right in such circumstances to receive compensation.

This was the approach followed by European countries and the hydrocarbons-rich new republics emerging from the break-up of the Soviet Union when in 1994 they signed the Energy Charter Treaty.[26] On the basis that cooperation between European firms and the new republics could be a positive sum game, the Treaty established detailed rules meant to provide the trust required to carry out such cooperation. But form a formal point of view the Treaty rules applied to all the countries receiving foreign energy investments, not only the new republics. That is why, paradoxically, the Treaty, originally conceived by many European countries as a mechanism to protect Western investors undertaking oil and gas energy projects in the former Soviet republics, has become the instrument for foreign investors in renewable energy projects to sue Spain and other European countries for alleged non-compliance with the Treaty.

The renewable resources paradox

In some electricity power plant investment projects a problem not unlike the “trust game” might crop up as a result of the interaction between the arrangements set up to determine market prices –designed at a time when combined cycle gas power plants were in a period of expansion and expected to determine (marginal) market prices –and the gradual success of renewable energies. A group of economists from the Saudi Arabian research centre have called this “the clean energies paradox”.[27]

[26] The Treaty can be referred to at https://energycharter.org/process/energy-charter-treaty-1994/energy-charter-treaty/

[27] BLAZQUEZ, Jorge, BOLLINO, Carlo Andrea, FUENTES, Rolando & NEZAMUDDIM, Nora, “The Renewable Energy-Policy Paradox”, King Abdullah Petroleum Studies and Research Center

This is so because since the pioneer reforms in the United Kingdom in the mid-1990s, spot electricity markets have been organised following a "marginalist" principle of price fixing, in such a way that the wholesale price of electricity is that of the highest bid necessary to meet global demand during the corresponding time interval. However, as renewable energy is always included, at a zero o very low price, in the supply schedule, when it is sufficient on its own to satisfy demand, the market price drops to zero. This may be good for consumers, but deprives all electricity producers of income and acts as a deterrent to new investments.

The International Energy Agency refers to this problem in its most recent report, when it states that "current electricity market designs are not always ready to tackle the challenge of rapid changes in the generation mix. The income in the wholesale markets is usually insufficient to promote new firm investments in generation capacity, which could jeopardise the reliability of the supply if not dealt with adequately"[28].

Therefore, it would seem clear that a growing influence of renewable sources of electricity will make it necessary to thoroughly review the electricity price-setting systems, in order to prevent the disturbing "trust game" that it provokes for investors in electricity power stations.

III. Combating climate change

1. The climate change problem

As a result of a build-up of CO_2 and other "greenhouse effect" gases in the Earth's atmosphere, scientists from the Intergovernmental Panel on Climate Change (IPCC)[29] estimated in their most recent study that human activity already raised the Earth's global

(KAPSARC), 2016, available at file:///C:/Users/usuario/Downloads/KS-1650-DP045A-The-Renewable-Energy-Policy-Paradox.pdf.

[28] WEO, *op. cit.*

[29] The IPCC was established in 1988 by the World Meteorological Organisation and the United Nations Environment Programme to periodically assess global warming from a strictly scientific perspective.

mean surface temperature[30] by approximately 0.87ºC in the period 2006-2015, when compared to the average temperature in 1850-1900 (a period considered representative of the "pre-industrial" period); and that this "anthropogenic" global warming keeps increasing by 0.2ºC every decade[31]. Those estimates refer to the global mean temperature of the Earth's surface, and are consistent with a much higher warming at certain seasons and in certain world regions –such as the Antarctic, where warming is estimated at between twice and three times as high as the global average-.

Most scientists consider that this global warming will have many adverse effects, including:[32]

- A rise in the sea level, as a result of the melting of the polar ice caps, which would submerge low-lying islands and land zones.

- An increase in the number and severity of extreme meteorological phenomena (droughts, hurricanes, floods, etc.) with a potentially devastating impact on many parts of the world and serious social and political consequences (famine, large-scale migrations, etc.).

- A serious impact on many ecosystems and biodiversity –which would involve the extinction of many species, unable to adapt to the new climatic circumstances-, and the appearance of tropical illnesses in regions they had never affected before.

The effects could be particularly severe if the temperature rise were to exceed 3 degrees or more. In such scenarios, the Himalayan glaciers would melt, which would alter the courses and discharges of the rivers on the Indian subcontinent, one of the world's most densely populated zones; the melting of the polar ice caps and the

[30] In English, *global mean surface temperature,* or abbreviated to GMST.
[31] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), "Global Warming of 1.5ºC. Summary for Policymakers", 2018, available at https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/.
[32] Despite the scepticism shown by the Trump Administration on climate change, the Fourth National Climate Assessment conducted jointly by 13 federal agencies in the United States and published in November 2018 confirmed the seriousness of the potential damage that climate change could cause –and is causing- in the United States. The assessment is available at https://www.globalchange.gov/nca4.

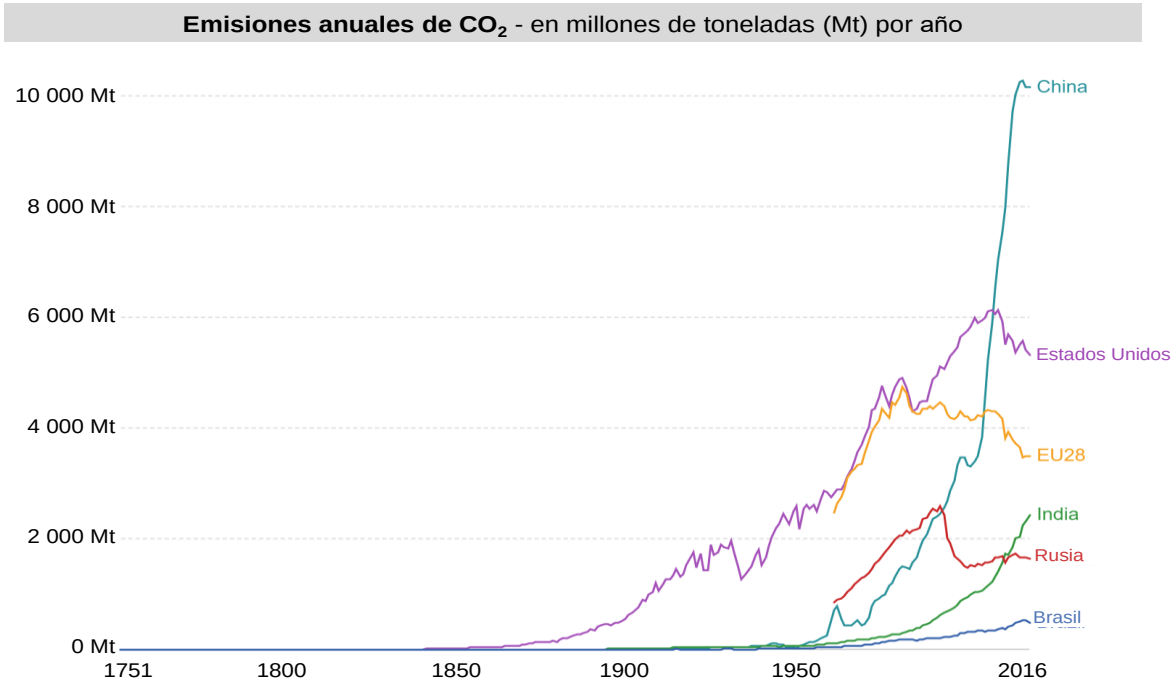
expansion of the water would raise the sea level, which would leave the low-lying coastal zones under water; the Amazon Basin could change greatly; and certain parts of the world would become desertified (possibly including part of Southern Europe). These changes would probably bring about large-scale population movements, as people fled from the worst affected zones. It is difficult to imagine that such migration could take place without causing wars or serious social conflicts.

Some of these effects are already inevitable, and make it advisable that the most affected countries, regions and communities take measures to adapt. The international community must also take the measures required to mitigate the temperature increase and, thus, contain the adverse impacts of warming and the risk of an uncontrolled one.

The amount of cumulative CO_2 in the atmosphere at the end of 2017 was approximately 2.2 trillion tonnes and it is still increasing at a rate currently close to 42 billion tonnes[33] per year, a rate that could rise to 52-58 billion in 2030 if States merely comply with the modest limits they have agreed so far. That level of emissions would foreseeably cause a temperature rise by 2100 of no less than 3ºC.

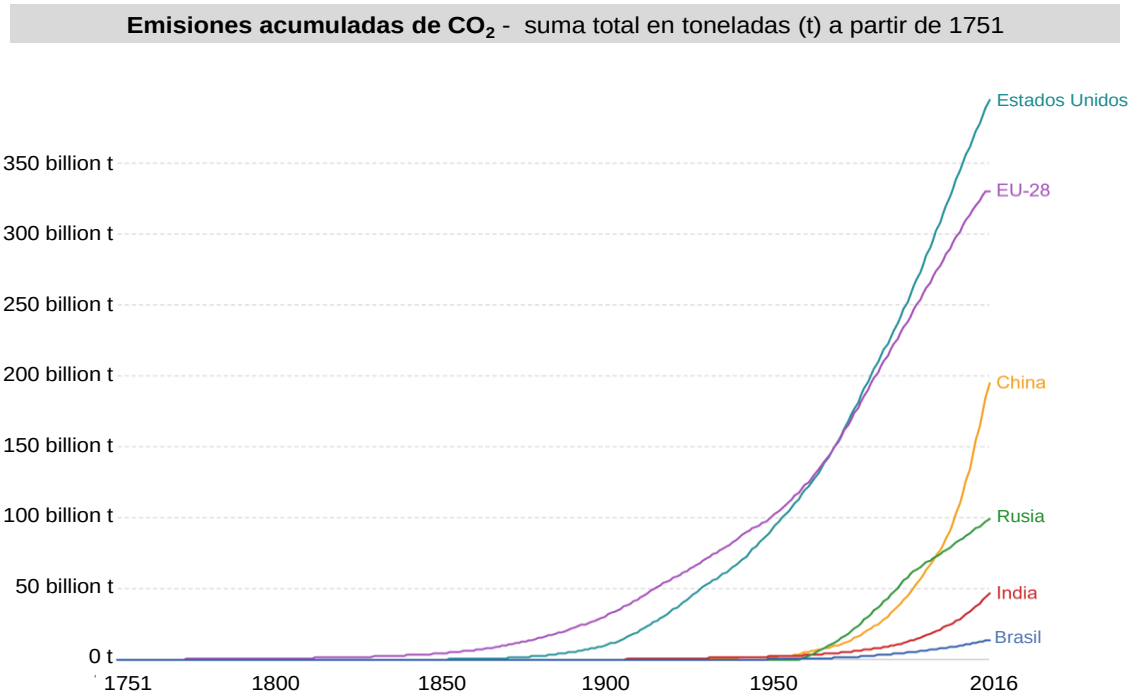
As the enclosed graphs show, the main emitters of CO_2 were traditionally the United States and the rest of the industrial countries, and they still account for most of the CO_2 that has built up in the atmosphere. Yet China, and to a lesser extent, India, Brazil and other emerging economies are rapidly increasing their annual emissions, China now being the world's main CO_2 emitter. However, China's cumulative emissions are still much lower than those emitted so far by industrial countries.

[33] Climate change experts generally use the term "gigaton" (abbreviated to Gt) when referring to a billion metric tonnes of CO_2 (i.e., $GtCO_2$).



Source: Global Carbon Project (GCP); Carbon Dioxide Information Analysis Center (CDIAC); adapted from OurWorldInData.org

Annual CO_2 emissions – in millions of tonnes per year. China; United States; UE 28; Russia; Brazil.



Source: Global Carbon Project (GCP); Carbon Dioxide Information Analysis Center (CDIAC); adapted from OurWorldInData.org

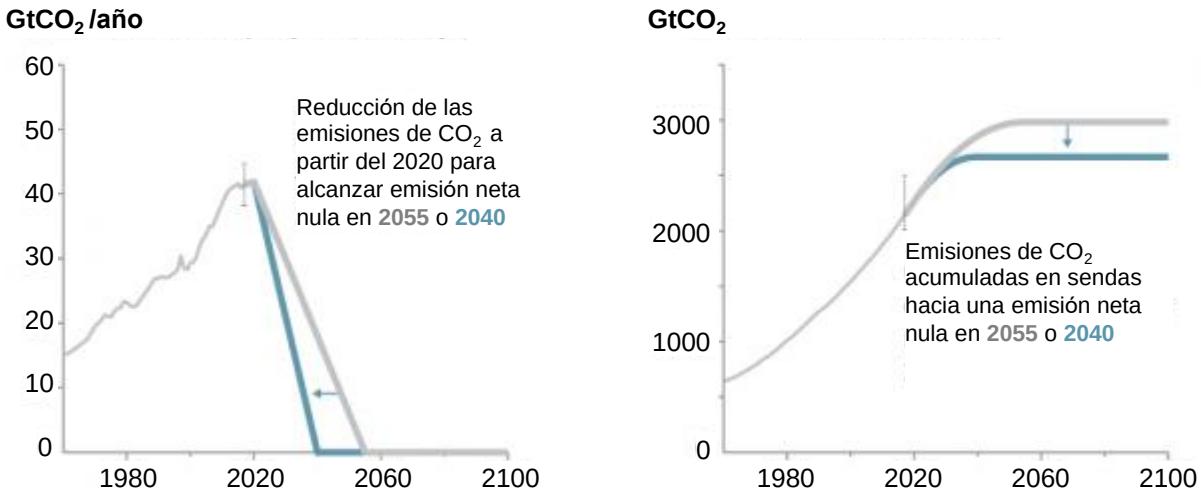
Cumulative emissions of CO_2 – some total in tonnes as from 1751. United States; UE-28; China; India; Russia; Brazil.

To make sure that in 2100 the temperature increase does not exceed 1.5ºC, the following will be necessary:

- That the annual global CO_2 emission rate is reduced as from 2020, in such a way that the additional amount emitted up to 2050 does not exceed 580 billion tonnes, so that the total cumulative CO_2 in the atmosphere does not surpass 2.8 billion tonnes.

- That a negligible net global emission rate is achieved by around 2050.

This great effort can be seen in the following graphs, which show annual and cumulative emissions:



Source: IPCC Special Report 1.5 October 2018

Reduction in CO2 emission as from 2020, to reach a negligible net emission in 2055 or 2040.
Cumulative CO2 emissions on the way towards a negligible net emission in 2055 and 2040.

2. From Río (1992) to Paris (2015)

Aware of the global nature of the problem and that CO_2 and other greenhouse gases emissions from anywhere in the world build up in the atmosphere regardless of their origin, in 1992, during the so-called “Earth Summit” in Río de Janeiro, the “United

Nations Framework Convention on Climate Change" was approved, with the deliberate aim of limiting the emissions of such gases.

Although that first Convention did not commit signatories to any specific emission-reduction targets, it was agreed that they would hold periodical meetings -known as "Conferences of Parties" (COPs- to discuss emissions trends. The most recent of these, -COP 24-, took place on December 2-15, 2018 in Katowice (Poland).

Combatting global warming is politically difficult, because:

- The benefits –i.e. the prevention of catastrophic phenomena- will be obtained by future generations, but the cost involved must be paid for by today's citizens and voters.

- It involves a classic "free rider" problem, because any CO_2 emissions raise the global level in the atmosphere and harms everyone, without anybody having an incentive to reduce their own emissions.

- As what matters is the cumulative level of CO_2 in the atmosphere and past emissions were mainly made by the industrialised countries, emerging countries (China, India, Brazil, etc.) now claim their right to emit their own.

- The total "decarbonisation" of the world economy would prevent a significant proportion of the already proven reserves of fossil fuels from being extracted ("stranded assets" or "unburnable oil"), causing the consequent economic damage to their owners.

- In contrast to initial expectations, cheap methods have not yet been developed to capture and store CO_2 in "sinks" or Carbon Capture Storage systems (CCS). Therefore, efforts must focus on limiting new emissions.

In keeping with the Framework Convention, in December 2007 several countries -including the United States –which after the presidential elections of November 2002, had Bill Clinton and Al Gore heading the Government- signed a Protocol in the Japanese city of Kyoto, whereby the industrialised countries and the Eastern European countries committed to reduce their emissions between 2008-2012 to below the 1990 levels.

The United States played an active role in its negotiation, encouraging a "flexibility mechanism" that made the CO_2 emission rights negotiable and transferrable, in such a way that one country could exceed the allocated emission limit if it purchased from another country's CO_2 emission rights, if that other country was able to do without them. That negotiability means that the total emissions are reduced where they can be achieved at a lower cost. The idea, which initially received a hostile reception from the environmentalists, was eventually accepted and the European Union itself adopted it to ration CO_2 emissions.

At Kyoto, every industrialised or developing country or group of countries was allocated a specific reduction percentage ((8% for the European Union, 7% for the United States 7%, 0% for Russia and Ukraine, etc.). However, the developing countries (China, India, Indonesia, Brazil, etc.) did not accept any quantitative commitment at all, because they argued that taking as a reference the 1990 emissions favoured industrialised countries.

The negotiations for that Treaty and its subsequent implementation –which did not bind emerging countries such as China and India and was not ratified by the United States, after George W. Bush's triumph in the Presidential Elections of 2000- revealed the serious difficulties involved in achieving an effective agreement on a world scale to reduce global emissions of greenhouse gases. Various obstacles became apparent:

- Firstly, some scientists and social groups in certain countries -especially, the United States, after the republican victory—cast doubts on the harmful global effects of that phenomenon or expressed confidence that future technological breakthroughs could

render it unnecessary to take immediate and drastic measures to cut down on gas emissions.

- Secondly, the major emerging countries, such as China and India, stressed that the cumulative CO_2 in the atmosphere up until that time had been emitted by the industrialised countries, which meant it was unfair to make the emerging countries give up their economic development to prevent the global build-up of gases, all the more so when gas emission levels per inhabitant were still exceptionally high in the United States and other major industrial countries.

At the beginning Russia did not share these opinions, because its high level of emissions in 1990 and the serious economic and industrial crisis that affected it after the demise of the Soviet Union gave it hope that it could sell emission rights ("hot air", as the environmentalists derogatively called it) to other countries. However, the renewed prospects of economic growth, the fact that China was not bound by the restrictions, the United States' withdrawal from the Protocol and President Putin's coming to power, all served to radically modify the Russian Authorities' viewpoint. They began to argue that the Protocol was harmful to Russia, because it erected barriers incompatible with the country's growth.

Despite the limited practical success of the Kyoto Protocol in limiting global emissions between 2008 and 2012, the European Union continued to advocate that all the industrialised countries should accept for the new period 2013-2019 the emission reduction percentages required to stabilise the CO_2 level in the atmosphere and succeed in ensuring that the temperature increase did not exceed 2ºC. The developing countries were expected to substantially modify their growth rate, even if they did not reduce their emissions.

But even the United States flatly refused and, as a result, the negotiations for a new and binding Protocol proved unfeasible. The serious financial crisis that shook the world after the bankruptcy of Lehman Brothers in September 2008 moved the Governments' and citizens' attention away from a distant problem like global warming.

Hence, the Copenhagen Summit of 2009 failed to achieve a new agreement to replace the Kyoto Protocol, even if it laid the foundations for the limited agreements reached in December 2015 in Paris at COP-21.

3. The Paris Agreement

In December 2015, still with a Democratic Party President in the United States, Barack Obama, COP-21 achieved in Paris an Agreement that, albeit non-binding, put an end to the "negationist" views of those who doubted the existence of an anthropogenic climate change and confirmed that a policy of "business as usual" would predictably lead to a mean temperature rise on the planet of over 4ºC by the end of the century, with catastrophic consequences.

The Paris Agreement:

- Set a limit of 2ºC on the mean temperature rise of the Earth by the end of this century, but with the intention of trying to ensure that it did not exceed 1.5ºC, given that the effects of climate change are unforeseeable and not linear.

- It was signed by nearly every country in the world and removed the old distinction between industrialised and emerging countries.

- All the countries that signed undertook to create their own "Intended Nationally Determined Contributions (INDCs)". Once voluntarily established by each country, their fulfilment will be subject to international verification.

- The extent to which the national targets have been achieved and their sufficiency for achieving the global target set will be measured every 5 years, using a common methodology.

- A "Green Climate Fund" will be set up with a minimum US$ 100,000 million to help emerging countries to develop climate change adaptation and mitigation policies.

Thus, the Paris Agreement did not establish legally binding emission-reduction targets and did not create a Leviathan to punish defaulters, but it merely established a transparency and collective monitoring mechanism of the voluntary emission reduction targets accepted by signatories.

4. The challenge of decarbonisation

As the International Energy Agency indicated in its Report in October 2018, the world CO_2 emissions, while stable in the 2014-2016 period, increased again by 1.6% in 2017 and will foreseeably continue to do so in 2018, thereby straying from the path required to achieve the Paris targets.[34]

To achieve those targets, the following will be necessary:

- Improving energy efficiency (i.e., less emissions per unit of GDP).

- Closure of coal power plants, unless they are equipped with CO_2 confinement and capturing systems. Here there have been no global breakthroughs: although the use of coal has decreased in the United States and Europe, its use is still on the rise in the emerging countries, led by China and India.

- Investment in renewable generation, making the most of their ongoing cheapening thanks to technological breakthroughs, with an increase in interconnections (to enhance the stability of the total output) and the development of mechanisms (such as, for instance, water pumping facilities) that offset the discontinuity of the wind and solar energy, as well as “smart networks” that adapt electricity demand peaks and cycles to the electricity generation profile.

- Use of natural gas –the fossil fuel that contaminates least- as a transition energy.

- Widespread use of electric passenger vehicles.

[34] WEO, op. cit.

- Applying the principle of “whoever pollutes pays” and, consequently, establish a carbon tax or a cap and trade emissions system. Although only the European Union, Australia and a limited number of countries or States (such as California or Quebec) have them in place, many others are thinking about it.[35]

  The lower the price of oil and other hydrocarbons, the higher the cost of the CO_2 ought to be.

4.1 Favourable Factors

Although the goals of the world’s decarbonisation and “energy transition” seem challenging, the fight against climate change could be boosted by certain factors:

- The fact that China and other emerging countries are realising that the measures to combat climate change also serve to fight against air pollution, a serious cause of death.

- The inclusion of the fight against global warming as a weapon for combating world poverty. As part of this strategy, the Millennium Development Goals approved by the United Nations in 2000 gave way in 2015 to the Sustainable Development Goals 2030, whose goal Num. 13 is, precisely, “to adopt urgent measures to combat climate change and its effects”.[36]

- The pressures exerted by many financial agents, such as insurers or private institutional investors -who have become “the new climate change warriors”- on firms or projects promoting fossil fuels.[37]

[35] The World Bank follows these initiatives in its “Carbon Pricing Dashboard”, available at https://carbonpricingdashboard.worlbank.org/
[36] UNITED NATIONS GENERAL ASSEMBLY, “Transforming Our World: Agenda 2030 for Sustainable Development”, Resolution A70/1, September 2015.
[37] RAVAL, Anjli & MOONEY, Attracta, “The new climate change warriors”, Financial Times, 28th December 2018.

- The acceptance of voluntary commitments to fight against global warming by major companies (like Shell, or those forming part of the "Energy Transitions Commission")[38].

- The initiatives in favour of decarbonisation promoted by sub-national organisations (States, cities, etc.), even in countries like the USA, whose Federal State does not wish to commit itself to firm undertakings on emissions.

4.2 Unfavourable Factors

However, such factors are outnumbered by many others that stand in the way of meeting the goals set in 2015 in Paris:

- The political priorities of emerging countries are to give to all their citizens access to energy at reasonable prices, not to limit CO_2 emissions (although the fight against pollution will require China to give up on coal).

- The general hostility shown towards nuclear energy –which has led to a lack of investment in this source of energy and even to the early shutdown of facilities- will make it necessary to replace its production with another more renewable source, and there will be a growing need for a new installed capacity of that nature.

- The popular backlash in many countries against price increases of electricity or fuels resulting from new environmental taxes or increases in the price of emission rights. That phenomenon became evident in France, in November 2018, with the violent demonstrations of the "Yellow Vest Movement" against the increase in taxes on diesel, which forced President Macron's Government to not go ahead with their

[38] The host of reports prepared by this coalition of large companies committed to combatting climate change can be found at http://www.energy-transitions.org/. The current Chairman is Adair Turner, former Chairman of the Financial Services Authority in the United Kingdom. See TURNER, Adair "Switch to a zero-carbon economy sooner rather than later", Financial Times, 23rd November 2018.

plans[39]. What happened in France could be just a first illustration of an "anti-Paris populism" of much wider scope.[40]

- The shale revolution has turned the United States into the world's main producer of hydrocarbons, which, together with the presidency of the republican Trump, has made the United States, far from being a Leviathan that forces other countries not to hold back in the fight against climate change, to align itself with Russia and the OPEC countries in opposing the Paris Agreement goals.

5. The European Union's dilemma

Aware of the prisoner's dilemma inherent in the international struggle against climate change, the European Union opted to carry on cooperating nonetheless: in November 2016 the European Commission launched an ambitious package of initiatives known as the Clean Energy Package, extending up to 2030, whose aim is for the European Union to deliver on its Paris Agreement's commitments.

As already explained, the European Union is interested in decarbonisation not only because of the fight against climate change, but also for energy security reasons, given that its fossil fuel production is low.

Yet these commitments also mean that the European industrial companies –especially the most energy-intensive ones- have to bear environmental costs that producers in other parts of the world do not have to put up with.

In an international free trade context, in the absence of frontier adjustments for carbon taxes this could lead to what Bernardo Velázquez, CEO of the Spanish multinational Acerinox, described as the "environmental paradox".[41][42] Let´s consider, as an

[39] "Macron forced into climbdown on fuel taxes to quell violent protests", Financial Times, 5th December 2018, first page.
[40] HOOK, Leslie, "Populism vs. Paris", Financial Times, 3rd December 2018.
[41] VELÁZQUEZ, Bernardo, "China and the environmental paradox", Expansion, 6th June 2016, available at http://www.acerinox.com/es/acerinox-insights/insights/China-y-la-paradoja-mediombiental-Bernardo-Velzquez-CEO-de-Acerinox.

illustration, the case of steel, where China, not subject to the environmental costs applicable in other parts of the world, has become a major net exporter in recent years. Now as the overwhelming majority of steel purchasers buy exclusively on the basis of its price, irrespective of how much CO_2 has resulted from its manufacturing or transportation, it could be the case that replacing European steel with cheaper imported Chinese steel leads to an increase in total CO_2 emissions, not only because of the greater emissions during the Chinese steel manufacturing process, but also due to the emissions involved in transporting that steel to Europe by ship, which adds a further 20%.

The theoretical solution to that problem was given by William Nordhaus, in his speech in December 2018 when he received the Nobel Prize for Economics: that all the countries that apply a price or tax on CO_2 emissions –whose ideal level would be US $50 per tonne- form a "climate club" and apply a border charge on imports coming from other countries.[43]

Unfortunately, with Republican Presidents in the White House -and especially Mr. Trump- this theoretical proposal seems to be fanciful.

IV. Conclusions

1. While oil was the predominant source of the world's energy and the OPEC countries –with Saudi Arabia at the head- its main producers, they were in a permanent "prisoner's dilemma", in which the collective wish to control the supply and raise the price was jeopardized by each producer`s temptation to overstep its quota to increase its revenue.

   Paradoxically, the restriction of world production sought by the OPEC's collusive agreement was favoured by two circumstances outside OPEC's control:

[42] Disclosure: the author served as independent director of Acerinox from 2011 to March 2019.
[43] NORDHAUS, William, "Climate Change: The Ultimate Challenge for Economics", Nobel Lecture in Economics Science, Stockholm University, 8th December, 2018, available at https://www.nobelprize.org/uploads/2018/10/nordhaus-slides.pdf

- The nationalization of the oil industry or the more stringent conditions on foreign concessionaires which several developing countries adopted –especially after oil-price increases-.

- Wars, economic sanctions and other political events that weakened the production and export capacity of some major producers, such as Iraq and Iran.

Although that coordinated action taken by the OPEC members caused sudden rises in the international price of oil –as in 1973-1974 and 1979-1980-, it found its main limit in the adverse reaction of the world economy and, thus, in the global demand for oil when price increases were excessive.

2. The Soviet Union never formed part of the OPEC and the political and economic instability during its collapse prevented it from playing a key role as an international oil exporter. However, as President Vladimir Putin came to power, Russia, which had always played a hegemonic role in the gas market, also came to be one of the major oil producers and, without formally joining the OPEC, liaised its actions with the group, giving rise to what came to be known as OPEP+.

3. Luckily, the shale revolution by decisively raising the US production of natural gas and has undermined the OPEC's capacity to control international oil prices and, as a result, weakened the geopolitical importance of the Middle East.

4. Together with that abundance of new unconventional oil, the European Union's strategy to diversify supply sources and favour renewable energy has reduced the risk of its members being forced to play a "chicken game" in which they might have to back down in the face of the threat of a supply cut. Thanks to that strategy, such threats could end up being a "called bluff".

5. The international "bathtubs" of oil and CO_2 are interconnected, given that when more oil is circulating and comes from the former, more CO_2 builds up in the latter and the more the Earth's temperature increases. To stop the bathtub of CO_2 from continuing

to fill up, it is necessary that at a certain moment –about midway through the century- oil ceases to flow out of its bathtub, which will immobilise the remaining reserves and put them out of use.

6. The international fight against global warming entails a gigantic “prisoner’s dilemma” which the international community will have to overcome without any Leviathan imposing discipline on free-riders, but just through the voluntary acceptance of emission limits, whose degree of achievement will be measured by the successive Conferences of the signatories of the United Nations Framework Convention with a common methodology and then made public.

   Although this fragile institutional set up may benefit from a growing support from civil society in many countries, it could be hindered not only by the “free riding” tendency in many countries, but also by the active opposition of the new coalition of major oil and gas producers -e.g. United States, Russia and Saudi Arabia- which became apparent in December 2018 at COP-24 held in Katowice.

The shale revolution and the international fight against global warming have changed energy geopolitics, yet the world’s energy supply and the fight against climate change will still be dogged by serious dilemmas in the coming decades.